THE PLANT DISEASE REPORTER

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PLANT DISEASE EPIDEMICS
and
IDENTIFICATION SECTION

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The Plant Disease Reporter is issued as a service to plant pathologists throughout the United States. It contains reports, summaries, observations, and comments submitted voluntarily by qualified observers. These reports often are in the form of suggestions, queries, and opinions, frequently purely tentative, offered for consideration or discussion rather than as matters of established fact. In accepting and publishing this material the Plant Disease Epidemics and Identification Section serves merely as an informational clearing house. It does not assume responsibility for the subject matter.

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Horticultural Crops Research Branch Plant Industry Station, Beltsville, Maryland
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IN THIS ISSUE

Virus Diseases: Establishment of the sugarbeet-curly top virus in the mid-West is indicated by a report from Wisconsin, where it first appeared in 1955, causing a disease of tobacco described by ROBERT W. FULTON, page 799; and from Illinois where H. H. THORNBERRY states that it recurred in 1954 and 1955 following the first definite determination in 1953, page 801. W. H. SILL, Jr., and R. C. PICKETT report that brome mosaic is widely distriubted in Kansas and suggest that it may become an important factor in forage plantings and on small grains as well, page 802. Lettuce calico in California is caused by a distinct strain of the tobacco ring-spot virus according to R. G. GROGAN and W. C. SCHNATHORST, page 803. PAUL R. FRIDLUND and T. H. KING report that the necrotic ring spot virus in plums is not affected by low temperatures in Minnesota, page 807. C. O. GOURLEY describes green petal, a virus disease of strawberry found in Nova Scotia, page 808. The cause of a citrus bud union abnormality, common in Florida, is not determined; it may be virus or genetic, according to GORDON R. GRIMM el al., page 810.

Nematodes (See also GOHEEN & BAILEY below): A. C. TARJAN reports increased yields from strawberry plantings in nematode-infested soil treated with N-244, page 812. Studies reported by T. W. YOUNG and GEO. D. RUEHLE, page 815, indicate that avocados tolerate nematode attack better than citrus. R. R. NELSON reports results of a survey indicating that nematode damage to corn in the Coastal Plain of North Carolina is more common and important than previously believed, page 818.

Polybor, used to correct boron deficiency in Washington, is compatible with materials applied for the control of apple powdery mildew, according to RODERICK SPRAGUE, page 820.

Phomopsis cinerascens seems to be primary among the several fungi associated with a fig disease reported by PAUL L. LENTZ and L. O. WEAVER, page 822.

Antibiotics: In tests reported by ROBERT B. MARLATT Acti-dione was not toxic to cantaloupe, page 824.

JOSUÉ AUGUSTO DESLANDES reports that environmental conditions in Brazil are not at all favorable to the development of powdery scab on potatoes, page 825.

ROBERT B. MARLATT describes brown stele of lettuce, a disease of undetermined cause in Arizona, page 827.

Mushroom Diseases: T. T. AYERS and E. B. LAMBERT report that chlorinated water controls several diseases, page 829. Magnesium is not likely to reach toxic proportions in casing soils, according to E. B. LAMBERT and T. T. AYERS, page 837.

ARNOLD J. ULLSTRUP reports crazy top on corn and some wild grasses including some new hosts, in Indiana, and occurrence of the sporangial stage of the pathogen, page 839.

Wheat Bunt Control in the Pacific Northwest: C. S. HOLTON and L. H. PURDY report that in commercial field tests HCB gave better control of soil-borne common bunt than mercury preparations, page 842. LAURENCE H. PURDY summarizes results of regional seed treatment tests for control of seed- and soil-borne common bunt, page 844; he also reports results of toxicity tests with seed treatment fungicides, page 850.

M. C. FUTRELL and G. W. RIVERS report that temperature affects susceptibility of seedlings of certain oat varieties and strains to Race 216 of crown rust, page 853.

J. W. GERDEMANN reports occurrence of Polymyxa graminis in red clover roots in Illinois, page 859.

M. I. TIMONIN and R. L. SELF describe damage to azaleas and other ornamentals in Alabama caused by Cylindrocladium scoparium, page 860.

Tree Diseases: Distribution and importance of sweetgum blight in Louisiana is reported by W. S. STOVER and E. RICHARD TOOLE, page 864. W. J. STAMBAUGH et al., describe the technique for determining that several bark and wood-boring beetles carried viable spores of the oak wilt fungus, page 867. T. W. JONES and T. W. BRETZ report that after the early stages infection by the oak wilt fungus may penetrate any part of the sapwood, page 872. CHARLES L. FERGUS reports a method of breaking dormancy of oak branches in the greenhouse, useful in disease studies, page 873. Wilt-resistant mimosa clones are available, according to E. RICHARD TOOLE, page 874.

The Cornell controlled temperature tanks are described by J. M. FERRIS et al., page 875.

Meadow nematodes were more common than root-knot nematodes in strawberry root samples from Massachusetts according to A. C. GOHEEN and J. S. BAILEY, page 879.

Brief Notes, page 881: Verticillium wilt of melons of California, by STEPHEN WILHELM and EUGENE E. STEVENSON. Leaf rust on orchard grass in New York, by D. A. ROBERTS and R. P. MURPHY. Dutch elm disease in Tennessee, by H. E. REED. Some tree diseases in Tennessee, by E. L. FELIX. Corrections, page 882. September weather, page 883. Manuscripts for the Reporter, page 884.

CURLY-TOP OF TOBACCO IN WISCONSIN

Robert W. Fulton

During July, 1954 a disease that had not been observed in previous surveys appeared on tobacco in Wisconsin. Growth of affected plants stopped abruptly. Edges and tips of immature leaves curled under and puckered, while leaves fully expanded at the time of infection yellowed and died after several weeks. Brown streaks were observed in the phloem regions of stems and petioles, but no micro-organisms were seen or cultured from affected tissues.

The disease was seen in many fields in both tobacco-growing areas of the State, but only a few infected plants were found in any one field. Judging from the number of normally developed leaves on infected plants, most of the infection apparently occurred early in July. Only an occasional new infection appeared later in the summer. By late August many infected plants had died.

The disease was readily transmitted in the greenhouse by grafting to Nicotiana tabacum L., N. rustica L., N. glutinosa L., tomato, petunia, and Datura stramonium L. On two occasions it was transmitted to tomato through dodder (Cuscuta subinclusa Dur. & Hilg.) but was not transmitted in a number of other trials. Numerous attempts by rubbing extracts of diseased leaves on healthy plants failed to transmit the disease.

In the greenhouse at 75° F during the winter months only a few infected plants died. Most graft-inoculated plants began to recover 2 to 3 weeks after development of acute symptoms and later made nearly normal growth.

Morgan and McKinney (2) from Maryland and Valleau (6) from Kentucky have described a similar disease and suggested it might be tobacco leaf curl. The Wisconsin disease differed from descriptions of Asiatic leaf curl (3) in the phloem degeneration, dying of the lower leaves, the absence of leaf enations, and in the recovery of infected plants in the greenhouse. These features suggested that the disease might be due to infection by the sugar beet curly-top virus. Thornberry and Takashita (5) have recently reported this virus and its vector from Illinois, and Sill and Pady (4) reported curly top of beets in Kansas in 1953.

Since transmission by the specific vector would provide strong evidence that the Wisconsin disease was curly top, beet leafhoppers were obtained from Dr. C. W. Bennett, to whom the author is also indebted for his interest and advice. Lots of 10 insects were caged for 24 hours on infected leaves and then transferred to a healthy plant on which they were allowed to feed for 4 days or more. Infection of tobacco was obtained in 3 of 5 trials with insects fed on diseased Datura stramonium, and in 1 of 2 trials with insects fed on diseased tobacco. No transmission was obtained from diseased tomato. Control lots of 10 insects not previously exposed to infected plants did not transmit the disease. The number of transmissions was small but sufficient to identify the beet leaf hopper as a vector and thus demonstrate that the virus concerned was the sugar beet curly-top virus.

Bennett (1) showed that the curly-top virus could be transmitted to healthy beets by pricking drops of phloem exudate from diseased beets into the crowns of healthy beets. Presumably this method was successful because the virus was introduced directly into the phloem. Tobacco was infected relatively easily with the Wisconsin virus by similar methods. In 3 trials, 8 of 13 tobacco plants were infected by pricking into axillary buds a drop of young diseased leaf extract diluted in phosphate buffer. In other trials 5 of 9 tobacco plants were infected by peeling back a flap of cortex, allowing the infectious extract to run beneath, then binding the flap back in place with grafting rubber.

Since the curly-top virus has a wide host range it may now be established on perennial plants in Wisconsin and other areas of the Midwest. Whether it becomes important on crop plants depends presumably on the behaviour of its vector.

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SUGARBEET CURLY-TOP DISEASE IN ILLINOIS IN 1954 AND 1955

H. H. Thornberry

Sugarbeet curly-top disease, first definitely identified in Illinois in 1953 (1), was present again this year as it was in 1954. Approximately 2 percent of the sugarbeet plants examined in 1954 had typical symptoms of curly top. A survey in 1955 revealed the following information.

Sugarbeet fields surveyed had from 2 to 5 percent curly-top-affected plants. These fields had not been treated with insecticidal dusts or sprays.

In tomatoes only an occasional plant showing curly-top symptoms was found. It was not determined whether these fields had been dusted or sprayed with insecticides.

Brittle root of horseradish, strongly suspected but not definitely proven to be caused by the curly-top virus, occurred in the three areas inspected. In the region around East St. Louis, there was from 1 to 3 percent of plants with brittle root symptoms. All fields examined had been dusted or sprayed with D.D.T. In the Peoria area, two plantings were examined. One which had been sprayed with D.D.T. had about 1 percent brittle-root-affected plants. The other planting which had not been treated with D.D.T. had about 3 percent brittle root. In the Chicago area, plants examined had approximately 2 percent brittle root. These plantings had not been treated with D.D.T.

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[1] Thornberry, H. H. and R. M. Takashita. 1954. Sugarbeet curly-top virus and curly-top disease in Illinois and their relation to horseradish brittle root. Plant Dis. Reptr. 38: 3-5.

BROME MOSAIC -- A THREATENING GRASS VIRUS DISEASE[1]

W. H. Sill, Jr., and R. C. Pickett[2]

During the past 3 years collections of smooth brome, Bromus inermis Leyss., infected by brome mosaic virus, Marmor graminis McK. (3), have been made in various counties in eastern, central, and northwestern Kansas. The westernmost verified collection was made near Norton. So far the virus has not been identified positively in nature in any other host, although many other plants have been infected in the greenhouse by the senior author and others (1, 3) using common abrasive inoculation techniques. No other methods of transmission have been found, although movement by direct abrasive leaf contact has been reported (2).

Some varieties of corn, rye, oats, and wheat have been damaged quite severely by the virus. Varieties of barley and sorghum have been infected but symptoms have been milder. These results agree essentially with those reported by McKinney (2). The virus has a wide range and several important range and pasture grasses may be quite susceptible (1). In Kansas the virus has persisted in the field in certain clones of smooth brome for many years and has moved gradually in some of these as the clones spread. Forage losses in diseased smooth brome were thought to be small until the spring of 1955 when many clones in the grass breeding nursery at Kansas State College became diseased. The most severe outbreak occurred in a small 3-year-old nursery where 116 plants were infected out of a total of 650. Several clones were severely stunted but many were intermediate in this respect or exhibited little or no apparent dwarfing. Typical streak and mosaic leaf symptoms appeared in April and on many clones persisted until late maturity of the old growth in July. Symptoms on most susceptible clones were severe also on the growth during July. On a few the leaf symptoms were more severe on this regrowth than on the spring growth. Susceptible plants were found in a wide variety of sources, including variable material from Minnesota, Texas, and recent plant introductions. A few clones in this nursery were diseased in 1954 and it now seems certain that considerable spread occurred during the year, possibly following mowing and cultivation.

Isolated infected plants were noted in other nurseries in the second year of growth and in selected plants moved to isolated breeding blocks for interpollination. No forage loss measurements have been made here as yet, but McKinney has reported up to 90 percent reduction in forage yield in smooth brome and 80 percent in orchard grass (2).

Since this disease appears to be of economic significance in certain smooth brome selections, is relatively widespread in Kansas, and is severe after artificial inoculation on several other small grains and grasses of economic importance, it would seem to be a potential threat. Consequently, it appears that those involved in grass research in other areas should watch closely for its presence and make every effort to check its spread, and especially eliminate it from breeding nurseries.

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TOBACCO RING-SPOT VIRUS -- THE CAUSE OF LETTUCE CALICO

R. G. Grogan and W. C. Schnathorst[1]

Calico, a virus disease of lettuce, was observed for the first time in a commercial field near Greenfield, California, during the 1953 season (1). At that time the disease occurred in only one field and was concentrated for the most part in a strip not more than 200 feet wide, running diagonally through the field. Insofar as the writers know, the disease did not recur during 1954 or 1955. The purpose of this investigation was to establish more definitely the relationship of the lettuce virus with two known strains of tobacco ring-spot virus by comparison of symptomatology, host range, properties and ability to cross-protect.

Methods and Materials -- All studies were conducted in a greenhouse at Davis, California, at temperatures of approximately 21°-25° C. Inoculations were made by rubbing infective plant sap onto healthy plants previously dusted with carborundum. At least 4 plants of each test host were inoculated in the host-range study and most tests were conducted 3 times. Recovery inoculations to Nicotiana tabacum L. were made from those hosts which exhibited no symptoms following inoculation to check for the presence or absence of virus.

The two strains of tobacco ring-spot which were compared with the lettuce calico virus were obtained from the American Type Culture Collection, and are listed in the Catalogue and Registry of the Plant Viruses (3) as the common strain no. 98, and the bean strain no. 100. They will be referred to in the text as strains 98 and 100, respectively.

Host Range and Symptomatology -- The three virus strains were inoculated mechanically to a number of hosts representing six families. All three produced similar symptoms which agreed closely with the descriptions of symptoms of tobacco ring-spot reported by Wingard (4) when inoculated to the following hosts: Beta vulgaris L. (sugar beet var. U. S. 41 and table beet var. Crosby's Egyptian), Spinacia oleracea L. (var. Viroflay), Zinnia elegans Jacq. (var. Giant Double), Phaseolus vulgaris L. (var. Bountiful), Pisum sativum L. (var. Shasta), Vigna sinensis Savi (var. California Blackeye No. 5), Petunia hybrida Vilm. (var. Hybrid white), and Nicotiana tabacum L.

Medicago sativa L. (var. California common), Trifolium repens L. (var. Ladino), and Lycopersicon esulentum Mill. (var. Improved Pearson), were not susceptible to any of the three virus strains, as evidenced by absence of local and systemic symptoms and failure to recover virus when check inoculations were made to N. tabacum.

Several hosts which are listed in Table 1 produced differential symptom expressions when inoculated with the three virus strains. Although any one of these hosts might serve to differentiate between at least two of the virus strains, the reactions of lettuce and Nicotiana glauca Graham were most striking and served to differentiate all three. The calico strain induced necrotic flecks, yellow mottling and ringspotting of lettuce (Fig. 1C) while strain 100 induced leaf deformity which was somewhat suggestive of hormone damage, but no mottling or ringspotting (Fig. 1B). The symptoms induced by strain 98 were intermediate between the other two in that both leaf deformity and mottling and ringspotting occurred. The calico virus produced only local symptoms in N. glauca, consisting of yellowish-green spots with necrotic margins and faint ringspots. No systemic symptoms developed and attempts to recover the virus from symptomless leaves of inoculated plants failed. Strain 98 induced irregularly shaped ring spots on inoculated leaves, but no systemic symptoms. However, the virus was recovered from the symptomless leaves. Strain 100 produced neither local nor systemic symptoms and the virus was not recovered.

Properties -- The lettuce calico virus was compared with strain 98 with regard to dilution-end-point, inactivation in vitro, and thermal inactivation point. For determination of the first two properties infectious juice from lettuce was used and for the thermal inactivation tests infectious juice from N. tabacum was used. The points at which inactivation occurred were: dilution, 1-1000 for the lettuce calico virus and 1-100 for strain 98; aging in vitro at 23° C, between 72 and 96 hours for lettuce calico virus and between 36 and 48 hours for strain 98; thermal inactivation was between 65° and 70° C for both viruses.

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Table 1. Comparison of symptomatology of several hosts inoculated with the lettuce calico virus and the tobacco ring-spot strains 98 and 100.

Host	Lettuce calico virus		Tobacco ring-spot strain 98		Tobacco ring-spot strain 100	
	Local	Systemic	Local	Systemic	Local	Systemic
Lactuca sativa L. (vars. Great Lakes and Imperial 615)	chlorotic ring-spots and necrotic flecks	yellow mottle and ringspotting; necrotic flecks and stunting	chlorotic ring-spots	leaf deformity resembling hormone damage with some yellow mottle and ringspotting	none	leaf deformity similar to strain 98, but no mottle or ringspotting
Lactuca serriola L.	necrotic flecks	necrotic flecks, occasional vein-banding and stunting; sometimes lethal	chlorotic spots	yellow mottle; eventually masked	same as strain 98	same as strain 98
Tagetes erecta L. (African marigold, var. Guinea Gold)	chlorotic spots	faint yellow-green mottle; eventually masked	same as calico virus	mottle formed by numerous white etched ring-spots	same as calico virus	none but virus was recovered
Citrullus vulgaris Schral. (Watermelon, var. Blue Ribbon Striped Klondike)	chlorotic spots or small necrotic lesions	none, virus not recovered	necrotic lesions	occasional necrotic ring-spots	necrotic lesions	none - virus not recovered
Trigonella foenum-graecum L.	chlorotic spots	chlorotic mottle and white ring-spots	chlorotic spots later becoming necrotic	necrosis of stems and leaves, lethal	chlorotic spots	chlorotic mottle often lethal
Solanum tuberosum L. (Potato, var. White Rose)	necrotic lesions	none, virus not recovered	same as calico virus	same as calico virus	none	same as calico virus
Nicotiana glauca Graham	yellowish green spots with necrotic margins and faint ring-spots	none, virus not recovered	irregularly shaped ringed areas	none but virus was recovered	none	same as calico virus
N. glutinosa L.	necrotic lesions and large chlorotic spots with necrotic margins	large chlorotic spots with necrotic margins and occasional oak leaf pattern	large chlorotic spots with necrotic margins	same as calico virus	none	very faint oak leaf pattern
N. rustica L.	necrotic lesions and chlorotic ring-spots	chlorotic spots and ring-spots with necrotic margins; eventually masked	same as calico virus	same as calico virus	small necrotic lesions	none, virus not recovered

FIGURE 1. A -- Healthy Imperial 615 lettuce of same age as B and C. B -- Inoculated with strain 100. C -- Inoculated with lettuce calico virus.

Seed Transmission -- Tobacco ring-spot virus has been reported to be seedborne in petunia (2). Tests were conducted to determine whether or not strain 98 and the lettuce calico virus were seed-transmitted in lettuce. Several plants of Paris Island Cos and Imperial 615 lettuce were infected with the two respective viruses and allowed to set seed. Four hundred seeds from each virus-variety combination were planted in the greenhouse and the seedlings were examined for disease symptoms. Test inoculations to local lesion hosts were made to confirm or deny suspected diseased seedling plants. Strain 98 was found to be transmitted through approximately 3 percent of the seed of Paris Island Cos, but the calico virus was not. Neither virus appeared to be transmitted through the seed of Imperial 615 in these tests.

Identification of the Lettuce Virus -- Cross-protection tests involving the lettuce virus and strain 98 and 100 were made with Nicotiana tabacum as the test host. Similar tests were attempted with N. rustica, but were abandoned because of incomplete or poor systemic spread of the viruses in this host. The tests on N. tabacum were made so that all three viruses were tested on the same plant using individual leaves as a test unit. For example, a plant initially inoculated with the lettuce virus and which had expressed systemic symptoms and had recovered was inoculated with all three viruses at different leaf levels. Protection by the first virus was indicated if the second or challenge virus failed to produce symptoms.

Although results were somewhat erratic, evidence of strain relationship between the three viruses was obtained. Strains 98 and 100 protected against themselves and against each other and both gave very good protection against the lettuce virus. In repeated tests the lettuce virus protected against itself, but did not protect against either strain 98 or strain 100.

Discussion and Summary -- The differences in physical properties, host range, and symptomatology on some hosts between the two strains of tobacco ringspot virus and the lettuce calico virus are evidence that the latter virus is a distinct strain. On the other hand, the many points of similarity of the three viruses with regard to the above-mentioned characteristics and the ability of the two tobacco ring-spot strains to cross-protect against the lettuce virus indicate that the calico virus is a strain of the tobacco ring-spot virus group.

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SURVIVAL OF THE NECROTIC RING SPOT VIRUS IN PLUMS DURING PERIODS OF EXTREMELY COLD WEATHER

Paul R. Fridlund and T. H. King[1]

Since indexing for the necrotic ring spot virus of Prunus in Minnesota has been done during winter months, it appeared important to learn if this virus remained active in the aerial portions of trees exposed to extremely cold weather. Presumably, if cold weather would partially or completely inactivate the virus, then routine indexing of trees, to determine the prevalence, severity and distribution of the virus, should not be done at that time of year.

Immediately preceding a period of 10 days of cold weather ranging from 2° above to 20° below zero F (Figure 1), budwood was collected on January 29, 1952, from eight known infected Mount Royal prune trees (Prunus domestica) and from one known infected Monitor plum tree (Prunus salicina x Prunus americana). Each Mount Royal tree was budded into one Prunus tomentosa seedling and the Monitor tree into two seedlings, using two buds per seedling. Again on January 22, 1954, when a similar cold period of 13 days ranging from 5° above to 25° below zero had occurred (Figure 1), budwood was harvested from six known infected Mount Royal trees. Each of these trees also was budded into two P. tomentosa seedlings, using two buds per seedling.

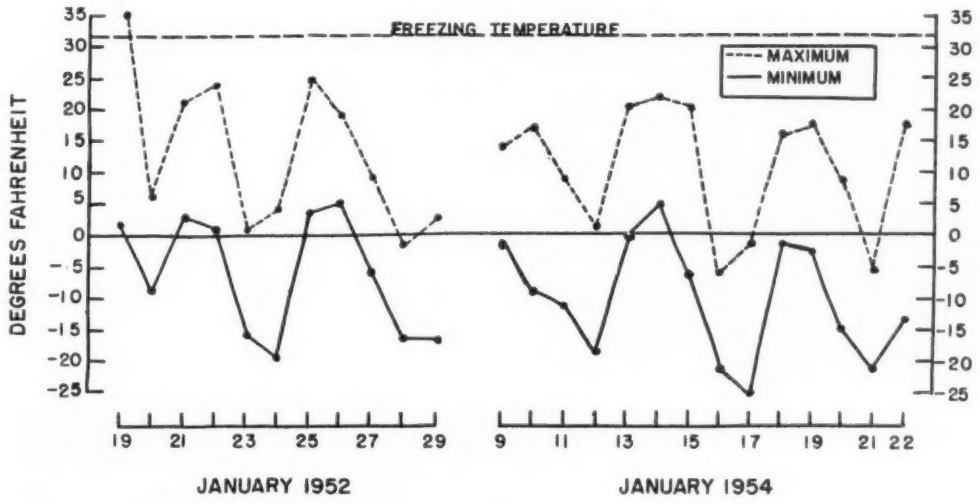

FIGURE 1. Maximum and minimum temperatures in the periods preceding harvesting of experimental budwood

All P. tomentosa seedlings inoculated in these two experiments developed typical necrotic ring spot symptoms 3 weeks after the inoculations were made. The virus was transmitted in all cases, and, as far as could be determined, remained active and unchanged throughout these periods of low temperatures. These results also indicated that this virus probably cannot be inactivated by low temperatures above those that are not also lethal to the host plants.

MINNESOTA AGRICULTURAL EXPERIMENT STATION

[1] This project was financed through matching State and Federal funds received from the Agricultural Marketing Service, U. S. Department of Agriculture, under provision of the Agricultural Marketing Act of 1946. Paper No. 3418 of the Scientific Journal Series of the Minnesota Agricultural Experiment Station.

GREEN PETAL OF STRAWBERRY IN NOVA SCOTIA[1]

C. O. Gourley[2]

In 1952, during a survey of the strawberry plantings in the Annapolis Valley of Nova Scotia, abnormal flowers were noticed on a few plants of the variety Senator Dunlop. The same flower abnormality was seen in all plantings examined in 1955 and its incidence ranged from a few plants to approximately 5 percent in the individual plantations. Strawberry growers report that this condition has been present in Nova Scotia for a number of years.

The most obvious symptoms occur in the flowers (Fig. 1). Plants which otherwise appear normal produce flowers with dwarfed and in most cases pale-green petals. Occasionally one or more of the petals on a diseased flower will be red or a single flower will bear dwarfed petals of various shades of red. Some flowers are sterile. Fertile flowers form a small, hard, green receptacle which remains dwarfed and does not ripen. The achenes stand out from the receptable and appear unusually large. The new foliage formed on diseased plants is dwarfed, slightly cupped, and pale-green with chlorotic margins. Leaf petioles are extremely short in contrast to the petioles of normal foliage. In most cases the short, thickened runners arising from infected plants produce extremely dwarfed runner plants. Infected plants may collapse and die during July and August.

FIGURE 1. Strawberry plant showing green petal condition in contrast to normal flower.

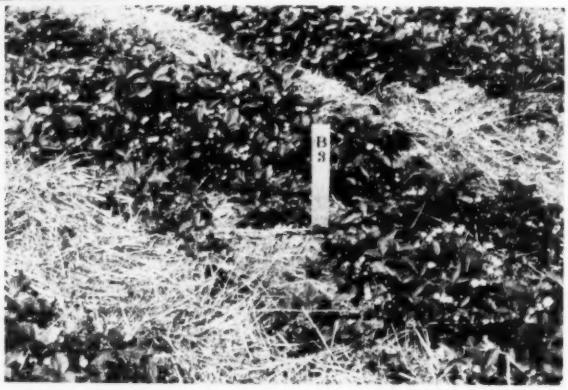

FIGURE 2. Strawberry clone exhibiting systemic condition of green petal disease.

[1] Contribution No. 1494 from the Botany and Plant Pathology Division, Science Service, Canada Department of Agriculture, Ottawa, Ontario.

[2] Assistant Plant Pathologist, Plant Pathology Laboratory, Kentville, Nova. Scotia.

The disease is considered systemic because runner plants originating from an infected mother plant show symptoms of the green petal condition (Fig. 2). Most runner plants of an infected clone show symptoms of infection in the first fruiting year while a few runner plants of the same clone will not show the disease until the following year. These latter plants are generally located at the second or third node on a runner, which indicates that they became established late in the previous season and did not form fruiting buds.

Infected plants lifted from the field at the late bloom stage in 1953 and again in 1955 succumbed within 2 weeks after being placed in the greenhouse. Attempts to index in the field by means of runner grafts on the indicator plant Fragaria vesca, in July 1955, did not succeed as the donor plants failed to survive the hot, dry weather of that period.

Since a large proportion of the diseased plants examined in commercial plantings in 1955 were original sets it is evident that not only were they infected before planting in the field but that the symptoms are not readily detected under the matted row system of culture unless the bloom or fruiting stems are present. The green petal condition was present in the plants from which this stock was secured. The varieties Senator Dunlop, Temple, and Catskill have been found to show the above-mentioned symptoms.

Green petal of strawberry as it occurs in Nova Scotia is in general similar to the new virus disease which Posnette[3] found in England.

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[3] Posnette, A. F. 1953. Green petal - a new virus disease of strawberries. Plant Path. 2 (1): 17-18.

A BUD UNION ABNORMALITY OF ROUGH LEMON ROOTSTOCK WITH SWEET ORANGE SCIONS

Gordon R. Grimm, T. J. Grant, and J. F. L. Childs

Examination of bud unions of Rough lemon rootstock with sweet orange scions in widely separated groves in the citrus areas of Florida have shown a bud union abnormality, described herein, to be very common.

On the trees examined the location of the bud union was usually determined by a slight to pronounced bulge. Upon removal of the bark at the union we found a dotted to continuous line of orange-yellow discoloration on the inner bark surface associated with rounded points and pegs that extend from the bark into corresponding depressions in the wood (Fig. 1). We scraped off the cambium and phloem layers along the line of protuberances and found that the tissue with normal cell color, indicative of functional phloem, was very thin and that the underlying tissue graded from orange-yellow to brown, indicative of non-functional phloem. In addition to the abnormal bud union there frequently were scattered pits in the wood of the Rough lemon rootstock as far down as the crown roots.

Observations were made during the months of March through July in more than 40 widely scattered groves. Random observations of trees in each grove revealed the presence of the bud union abnormality in nearly every tree. Observations made during the dry months of March to May showed the symptoms to be more severe than in July after the rains and subsequent tree growth had begun. New phloem tissue had formed at the union and there was less orange-yellow discoloration evident. This development of new phloem at the union would appear to be a means for overcoming the adverse effects of the abnormal condition.

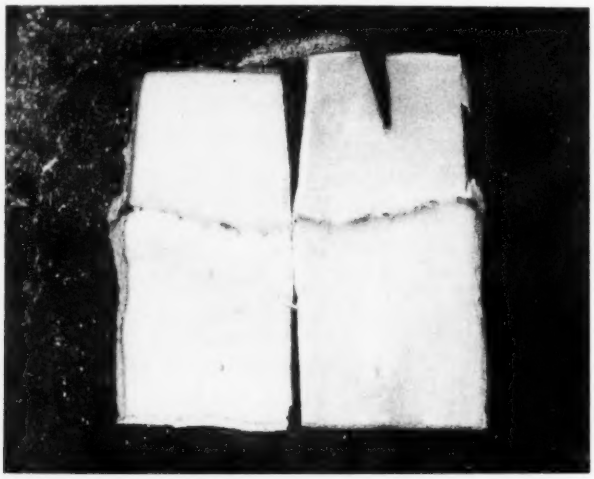

FIGURE 1. -- Bud-union abnormality of Rough lemon rootstock with sweet orange scion. Note degeneration of connecting tissues.

Limited observations were made of bud unions of Rough lemon rootstock with grapefruit scions and of sour orange rootstock with sweet orange scions. In the trees examined the striking symptoms described above were not evident. However, some scattered bark pegs and corresponding pits in the wood were found on a few Rough lemon rootstocks below the union with grapefruit scions.

The observations that initiated the present study were made on trees manifesting symptoms described by Swingle and Webber (5), Rhoads (4), and Childs (2) for citrus blight. We have found the bud union abnormality of Rough lemon rootstock with sweet orange scions to be present in trees with blight and generally more severe than on apparently healthy trees. A possible relationship between the bud union abnormality and blight warrants further consideration.

There is a distinct possibility that the reported bud union abnormality on Rough lemon is

caused by a virus or virus complex. The symptoms of cachexia, or Orlando tangelo disease (1, 3), are recognized in certain citrus hosts as yellow to brown discolored phloem with pits and pegs that begin near the union. Although the symptoms for cachexia on Orlando tangelo and some of the mandarin varieties are more extensive and extreme than the bud union symptoms of the Rough lemon-sweet orange combination, their similarity strongly suggests a possible relationship. A more direct relationship between cachexia and the bud union abnormality has been indicated from observations made in a grove of 20-year-old sweet orange trees on Rough lemon rootstock. The bud unions of each tree showed severe abnormality symptoms. Six years ago many of these trees were trunk-grafted with scions of Orlando tangelo. Where graft unions were successful the sweet orange tops were cut off and an Orlando tangelo top has subsequently developed. These tops now growing from the old stumps show striking symptoms of cachexia, as well as abnormalities at the line of the sweet orange-Rough lemon union. We checked the source of the Orlando tangelo scions with the grower's records and upon examination in the field, we found the parent trees, now 12 years old, to be free from cachexia symptoms in the tops and in the bark at the bud unions. It would appear that the source of the cachexia infection was from the sweet orange trees on Rough lemon rootstock which were showing the typical bud union abnormality symptoms and not from the Orlando tangelo parent trees.

The bud union abnormality might possibly be due to an inherited incompatibility of sweet orange scions on Rough lemon rootstocks. However, the finding of some trees without the bud union abnormality and trees in the same grove with the same variety of sweet orange scion with varying degrees of symptom expression makes it difficult to explain the occurrence of symptoms on the basis of inherited incompatibility alone.

Regardless of whether the bud union abnormality is due to a virus or to a genetic incompatibility, it would be bud-propagated and therefore should be taken into consideration in the selection of budwood and of rootstocks.

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HORTICULTURAL CROPS RESEARCH BRANCH, AGRICULTURAL RESEARCH SERVICE, U. S. DEPARTMENT OF AGRICULTURE

USE OF 3-P-CHLOROPHENYL-5-METHYL RHODANINE AS A SOIL AMENDMENT FOR NEMATODE-INFECTED STRAWBERRIES[1]

A. C. Tarjan

Summary

3-p-chlorophenyl-5-methyl rhodanine (N-244) was applied to soil in which young strawberry plants were growing. Yield data obtained the following year showed that the most effective treatment was 300 lbs. per acre, which resulted in an increase of 22 quarts of berries per 80 feet of row over untreated controls. Nematode populations in treated soil were lower in numbers than in untreated soil.

Meadow or root-lesion nematodes, Pratylenchus spp., have of late acquired a notoriety that promises to equal that of the root-knot nematode (5). The fact that the locus of infection exists in the parenchymatous cortical tissues of the roots where colonies of the nematodes establish themselves makes control of these pathogens with chemotherapeutants particularly difficult. Strawberries are one of the many crop plants that are affected by meadow nemas. Recent publications indicate that infected plants may be successfully treated by immersion in water at 124° F for 5 minutes (3). Such stock should then be planted in sites previously treated with soil fumigants.

Various tests have been reported indicating the therapeutic efficacy of 3-p-chlorophenyl-5-methyl rhodanine (hereafter referred to as N-244) against root-knot nematode infections (4, 6, 7). When a station strawberry field, planted a few months previously for investigation of varietal yield, was discovered to be naturally infected mainly with meadow nemas, Pratylenchus penetrans Cobb, an experiment was instituted in July 1954 to test the nematocidal effect of the chemical when used as a soil amendment.

Procedure

Treatments consisting of N-244 at rates of 500, 300, 100 and 0 lbs. per acre were applied to rows 20 ft. long in a systematic arrangement. The experimental area consisted of single rows of Catskill and Sparkle and 2 alternating rows of Howard 17 variety strawberries. The proper amount of chemical in powder form was incorporated into a small quantity of sand, distributed evenly within an area extending 1 ft. from the base of the plants on each side of the row, and hoed into the soil to a depth of 4 to 6 inches.

Results

No injury to plants was observed as a result of treatment. Data obtained the following season showed that treatment with N-244 at rates of 500 and 300 lbs. per acre resulted in a higher yield of marketable berries than the lower treatment rates (Table 1). Figure 1 illustrates the

FIGURE 1. Average yield per picking of 80 ft. of row of strawberries treated with increasing dosages of N-244.

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[1] Contribution No. 871 of the Rhode Island Agricultural Experiment Station, Kingston.

Table 1. The effect of N-244 as a soil amendment on total yield in quarts of strawberries.

Treatment	Strawberry Varieties [a]				Total yield per treatment [b]	Av. yield per picking [b]
	Catskill	Howard 17 Row B	Sparkle	Howard 17 Row D		
N-244 @ 500 lbs./acre	27.0	22.0	44.5	18.0	111.5	10.0
N-244 @ 300 lbs./acre	32.0	15.0	43.5	22.0	112.5	10.0
N-244 @ 100 lbs./acre	26.5	20.0	27.5	23.5	97.5	9.0
Untreated Controls	24.0	14.0	32.5	19.5	90.0	8.0
Variety yield total [b]	109.5	71.0	148.0	83.0		
Av. yield per picking	10.0	6.5	13.5	7.5		

[a] Yield per 20 ft. row

[b] Yield per 80 ft. row

Table 2. The effect of N-244 as a soil amendment on the approximate number of plant-parasitic nematodes present in a pint soil sample.

Treatment	Catskill	Howard 17-Row B	Sparkle	Howard 17-Row D	Average
N-244 @ 500 lbs./acre	1700	2600	500	500	1325
N-244 @ 300 lbs./acre	2900	2300	300	400	1475
N-244 @ 100 lbs./acre	1900	2000	100	3300	1825
Untreated Controls	3900	8900	700	1400	3725

average yield per treatment per picking.

Berries from all treated plots were tasted during harvesting and judged to be free from "off-flavors".

After yield data were obtained, soil from 3 locations within each treated row was combined, thoroughly mixed, and placed in a pint sample jar. The pH of these soil samples was found to be from 5.1 to 6.2 with no significant differences between treatments. Each pint sample of soil was processed through various sized sieves and the residues were put in the Baermann funnel for 24 hours according to the technique suggested by Christie and Perry (1). The following day the liquid contents of each funnel were passed through the Buchner funnel (2).

Residues retained in this method were suspended in water, made up to 100 ml. volume with water, and the numbers of plant-parastic and saprobic nematodes were determined from aliquots and calculated to represent the approximate total numbers present in the samples. Since counts of plant-parasitic nematodes bore the same relationship between treatments as did counts of both the saprobic and total nematode populations, only these are presented in Table 2. Here it can be seen that the average number of plant-parasitic nematodes was reduced as a result of soil treatment. Also worthy of note was the lower number of nematodes present in the Sparkle variety as compared to other varieties.

The most prevalent plant parasite present was Pratylenchus penetrans. Other parastic and suspected parasitic nematodes observed were nemas belonging to the genera Tylenchus, Aphelenchoides, Paratylenchus, Psilenchus, Xiphinema, and Rotylenchus.

Discussion

From the results presented above, it appears that treatment with N-244 can increase yield appreciably and reduce the number of nematodes in the soil around the roots. Although an inspection of Table 1 shows that the difference in total yield between the untreated controls and N-244 at 300 lbs. per acre is only 22 quarts, it should be remembered that this represents the increase in yield of only 80 ft. of plant row space. Such an increase in yield in any extensive commercial planting would represent a considerable margin of profit over the cost of treatment which amounts to about 1 1/4 lbs. of chemical per 100 feet of row. These data are the results of one year's tests. Yield data will be obtained from this same experimental area in 1956.

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THE ROLE OF THE BURROWING AND MEADOW NEMATODES IN AVOCADO DECLINE

T. W. Young and Geo. D. Ruehle

Summary

Radopholus similis (Cobb) Thorne, which causes the "spreading decline" disease of citrus, and a closely related nematode, Pratylenchus brachyurus (Godfrey, 1929) Goodey 1951, are widespread on avocados in Florida. In general on avocados P. brachyurus is more numerous than R. similis, but under favorable conditions R. similis may build up to extremely high numbers as compared to P. brachyurus. The damage to avocado roots by individuals of both species is probably about equal. High populations of either or both nematodes apparently do not cause a systematic spread of decline or necessarily seriously retard top growth as in citrus heavily infested with R. similis. The implication is that avocados are somewhat more tolerant to attack by these nematodes than is citrus to R. similis.

The endo-parasitic burrowing nematode, Radopholus similis (Cobb) Thorne, was reported by Suit and DuCharme (3) as the cause of the "spreading decline" disease of citrus in Florida. In addition to R. similis they found several other plant-parasitic nematodes, including a closely related meadow nematode, Pratylenchus pratensis (de Man) Filipjev, associated with citrus feeder roots in healthy and decline areas. None of these were considered as probably contributing to spreading decline although, according to Steiner (2), the meadow nematodes apparently are the most destructive (on crops in general) and most widely distributed of the endo-parasitic nematodes.

To determine the advisability of replanting spreading decline areas with avocados without first treating the soil, DuCharme and Suit (1) examined avocado roots from such areas for infestation by R. similis and other parastitic nematodes. R. similis and a meadow nematode, P. pratensis (probably synonymous with P. brachyurus (Godfrey, 1929) (Goodey 1951), were found in roots from a young grove planted on untreated citrus spreading decline soil, and R. similis only in roots from a mature mixed planting of avocados and citrus. The mature trees in the area infested with R. similis only showed root and top symptoms of decline comparable to citrus in a decline area, whereas trees outside the area were healthy. From these observations they concluded that R. similis was the cause of a decline of avocado and that it was not advisable to plant avocados in areas of citrus spreading decline without proper soil treatment.

This evidence that R. similis was the causal agent in a decline of avocados was circumstantial only. Subsequent investigations, reported here, showed that R. similis and P. brachyurus were widespread and sometimes numerous on avocados. It was also found that under favorable conditions on avocados R. similis multiplied much more rapidly than did P. brachyurus. However, high populations of either or both nematodes did not cause a systematic spread of decline or necessarily greatly retard top growth as in citrus heavily infested with R. similis (5).

An examination for R. similis and P. brachyurus was made on roots from 60 Florida avocado groves growing on soils ranging from light sands through heavy sandy loams to the semilateritic sandy clay (Rockdale) soils of southern Dade County. R. similis and P. brachyurus were found in 26 of these groves, all on light sandy soils. P. brachyurus alone was found in 21 groves, mostly on light sandy soils, but also in a few groves on sandy loams and Rockdale soil.

Some idea of the incidence of these nematodes in typical groves was obtained by counting the adults of both species that emerged, upon incubation (4), from weighed field collections of roots from several infested groves. Some samples contained but few specimens of either nematode. The largest number of P. brachyurus recorded was 39 specimens per gram wet weight of root; of R. similis the largest number was 65. These figures doubtlessly would have been somewhat higher if larvae had been included.

On the average, P. brachyurus was more numerous than R. similis, although there were a few notable exceptions where the converse was true. Several groves had relatively heavy infestations of P. brachyurus with no R. similis being found. Others appeared to be about equally infested with both species. It was interesting to observe that the larger populations of both species often were from normal-appearing trees. This is in accord with the life habits of these

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[1] Florida Agricultural Experiment Station, Journal Series, No. 407.

nematodes. As roots are destroyed by their feeding, they migrate to healthy roots of the same plant or adjoining plants.

Both nematodes were found without distinct bias in good and poor groves. In some instances in the same grove, adjoining areas of healthy and unthrifty trees apparently were equally infested with both species and in other cases with P. brachyurus alone. There was no good correlation between the observable incidence of these nematodes and tree condition. Decline symptoms in the top may have been slightly more prevalent in a few areas examined that were infested with both species than in uninfested areas or those infested only with P. brachyurus, but these symptoms were not always characteristic exclusively of nematode attack. There was little to indicate a systematic spread of decline, as with citrus, in any case. Furthermore, in several groves receiving normal care, where the indications were that infestation by these nematodes was long-standing, the trees had remained productive. At most, only a few scattered trees had declined to the point of unprofitableness, but decline in avocados certainly is not peculiar to nematode-infested groves alone. This is in contrast to citrus, which usually goes out of production within a few years after infestation by R. similis.

On avocados R. similis and P. brachyurus penetrate primarily the cortex of unsuberized feeder roots. They do not often enter the stele and have not been observed in heavily suberized older roots. Decay organisms invariably follow these nematodes and help complete the destruction of roots at the points of nematode attack. Frequently roots are girdled and the distal portions killed. Without question this is detrimental to the tree, but it may be an insidious sort of effect which is not readily detected in the above-ground portions. Perhaps avocados are able to absorb limited amounts of water and nutrients through suberized or partly suberized roots. Also, it is known that avocados regenerate feeder roots rather readily. The capacity for some absorption through older roots plus profuse formation of new roots above the injury probably delays the appearance of distinct symptoms of decline in the top until the population of nematodes is extremely great. As well as could be determined by field observations and population studies, damage to root systems of avocados by both species was comparable when the infestations were equally heavy.

These observations raised the questions as to whether R. similis actually was more pathogenic than P. brachyurus to avocados, and if so, why? To answer these questions healthy avocado seedlings were grown in individual containers in sandy soil freed of nematodes by fumigation. Some of these were inoculated with R. similis by adding practically pure collections of several hundred living specimens to the soil in which individual trees were growing. An equal number of seedlings were inoculated in this manner with P. brachyurus, duplicating the R. similis inoculations with respect to number of specimens added. A few seedlings were inoculated with both nematodes, using equal numbers of each species. Other seedlings were grown in unfumigated sandy soil direct from about trees heavily infected with R. similis and lightly infected with P. brachyurus and a like number grown in soil from about trees heavily infected with P. brachyurus only. Several seedlings growing in fumigated sandy soil served as controls. Each container was provided with an independent drain and the entire series of 30 placed in a water-bath temperature tank which maintained the soil temperature between about 45° and 85° F. It was known that these nematodes would survive this minimum without harm and be quite active in about the upper half of this temperature range.

Beginning about 6 months after inoculation, roots were examined in situ periodically by carefully removing the soil from a portion of the root system. Feeder roots of R. similis-inoculated plants generally showed numerous lesions characteristic of attack by this species and were fewer in number than on control plants. Feeder roots of plants inoculated with P. brachyurus were more numerous and averaged fewer lesions than the R. similis-inoculated plants, but were in a slightly poorer condition than control plant roots. The controls had good root systems and, with one exception, were free of lesions that characterize roots attacked by these nematodes. Subsequent examination showed this exception to be lightly infected with R. similis and P. brachyurus, obviously through contamination from adjacent plants.

Roots samples were taken from each plant as examined for nematode population studies. An incubation technique (4) was used in extracting and collecting nematodes from the roots. All specimens (adults and larvae) that definitely could be identified as R. similis and P. brachyurus were counted under a stereomicroscope at 112X. Both species had entered the roots and were multiplying, with larvae present. The population of R. similis had increased greatly as compared to P. brachyurus in most instances. The number of specimens found in all the treatments with R. similis ranged from 4 to 469, with an average of 166 per gram wet weight of root. The number of specimens found varied from 2 to 57, with an average of 18, in the comparable treatments with P. brachyurus. In the six plants which were inoculated with practi-

cally pure collections of several hundred R. similis, the number of specimens of this species found per gram wet weight of root was from 110 to 469, with an average of 292. The six comparable inoculations with P. brachyurus yielded from 4 to 38 specimens of this nematode per gram, with an average of 15. Thus, from the same initial number, R. similis had increased approximately 19 times more than had P. brachyurus.

It was noteworthy that these six R. similis inoculated plants were smaller in size approximately a year after inoculation than the controls, whereas the six P. brachyurus inoculated plants were as large as the controls. In a general way, the population of R. similis was reflected in plant height and diameter as an inverse relationship. The height of the six R. similis inoculated plants was from 33 to 61 inches (avg. 42.3 in.) and the diameter, 2 inches above root crown, was from 0.462 to 0.658 inches (avg. 0.571 in.). The six control plants ranged in height from 42 to 58 inches (avg. 51.3 in.) with diameters from 0.477 to 0.721 inches (avg. 0.593 in.). There was no chlorosis or other observable difference in the tops to distinguish the R. similis-inoculated plants from the controls. The size as well as the appearance of the plants under all other treatments was comparable to the controls. Apparently under favorable conditions on avocados R. similis may increase tremendously in number, as compared to P. brachyurus, and become noticeably deleterious through sheer numbers.

DuCharme [2] reported usually finding from 50 to 75, and occasionally as many as 150, specimens of R. similis per gram wet weight in roots of declining citrus. Although in the avocado groves examined the population of R. similis was not often this high, the combined populations of R. similis and P. brachyurus no doubt frequently equaled or exceeded these figures for R. similis on citrus. Individuals of the two species appear to be equally pathogenic to avocado roots. There was a question, however, whether decline symptoms in the tops of infested avocado trees could be attributed definitely to these nematodes. Furthermore, while the tops of some inoculated avocado seedlings were retarded in growth slightly, distinct symptoms of decline were lacking, although the roots were more heavily infected with R. similis than the maximum reported for declining citrus. These observations suggest that avocados are somewhat more tolerant to attack by either or both of these nematodes than is citrus to R. similis.

It is barely possible that some cases of tolerance in avocados to parasitic nematodes may be accounted for through root stocks. A large variety of root stocks have been used under avocados and cannot be identified other than through records, which are rarely, if ever, kept for commercial plantings. Trees on these miscellaneous root stocks have been planted promiscuously in individual groves. Some may be more tolerant to nematode attack than others. This would explain why some trees show decline while adjacent trees remain healthy although all are about equally infected with parasitic nematodes.

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[2]Private communication from E. P. DuCharme, 1955.

NEMATODE PARASITES OF CORN IN THE COASTAL PLAIN OF NORTH CAROLINA[1]

R. R. Nelson[2]

Abstract

A preliminary survey throughout the Coastal Plain of North Carolina has indicated that at least 5 genera of parasitic nematodes are associated in high populations with corn in that area. Soil and root assays have shown that root-knot nematodes (Meloidogyne spp.) sting nematode (Belonolaimus gracilis), Tobacco stunt nematode (Tylenchorhynchus) claytoni), stubby root nematode (Trichodorus spp.), and meadow nematodes (Pratylenchus spp.) are present in problem fields throughout the region. The meadow nematode has the widest distribution of the five genera present. It was isolated from all but 3 of the 40 counties in which the survey was made. The stubby root nematode and the stunt nematode are scattered throughout the Coastal Plain with no apparent pattern of distribution. The sting nematode and root-knot nematode are present in but a few counties. The results of the survey indicate that nematodes are more widely distributed and are causing considerably more damage than previously believed.

A nematode analysis of soil and root samples collected from problem fields of corn throughout the coastal Plain of North Carolina has indicated that nematodes are much more prevalent and widely distributed on this crop and may be causing considerably more damage than is presently believed. Previous studies have shown that there are several genera of nematodes parasitic on corn (1, 2, 3). The importance of nematodes as parasites of corn is evidenced not only by actual damage to corn, but also by abundant population increases of certain nematodes on that host. Corn is commonly grown in rotation with high value cash crops such as tobacco, cotton, and peanuts, which are hosts to several of the genera of nematodes parasitic on corn.

Table 1. The prevalence and distribution of genera of nematodes on corn in the Coastal Plain of North Carolina.

Nematode	Number of counties isolated from[a]	Number of fields isolated from
Meadow (Pratylenchus spp.)	37	73
Root-knot (Meloidogyne spp.)	6	9
Sting (Belonolaimus gracilis)	4	5
Stubby root (Trichodorus spp.)	24	48
Tobacco stunt (Tylenchorhynchus claytoni)	22	45

[a] Based on a survey of 40 counties.

The present paper summarizes the results of a preliminary survey on the distibution of nematodes on corn in eastern North Carolina. Additional surveys undoubtedly will extend the present known distribution and prevalence.

High populations of one or more of the following nematodes are present in problem fields throughout the region: 1) root-knot nematode (Meloidogyne spp.), 2) sting nematode (Belonolaimus gracilis), 3) tobacco stunt nematode (Tylenchorhynchus claytoni), 4) stubby root nematode (Trichodorus spp.), and 5) meadow nematodes (Pratylenchus spp.) (Fig. 1). In problem fields, stunting of plants indicative of root injury attributable to nematodes has ranged from a few plants to as much as 80 percent in one 3-acre field.

[1] Cooperative investigations of the Field Crops Research Branch, Agricultural Research Service, U. S. Department of Agriculture and the North Carolina Agricultural Experiment Station.

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FIG. 1. THE PRESENT KNOWN DISTRIBUTION OF SPECIES OF NEMATODES PARASITIC ON CORN IN THE COASTAL PLAIN OF NORTH CAROLINA

The genera of nematodes found, and their distribution and prevalence on corn in the Coastal Plain of North Carolina, are presented in Table 1.

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COMPATIBILITY OF SODIUM PENTABORATE WITH APPLE POWDERY MILDEW SPRAYS[1]

Roderick Sprague[2]

Sodium pentaborate or Polybor is used on apples in north central Washington for the serious boron deficiency that occurs there[3]. Polybor is usually applied at the first or second cover sprays at the rate of 5 pounds per acre or approximately 1/2 pound per 100 gallons of water when applied at the dilute rate either by handgun or speed sprayer[4]. Information on the compatibility of Polybor with standard pesticide sprays was requested by the manufacturer and a grant-in-aid was furnished to cover all costs of the work[5]. Polybor was included in a number of sprays for control of apple powdery mildew on Black Jonathan apples at the Tree Fruit Experiment Station in the spring of 1955. In these fungicide-Polybor compatibility tests the combinations were applied in five-tree replicates by handgun at the pre-pink spray on April 19 (a very retarded season). Standard mildew spray schedules plus some experimental ones were followed at the pink spray on May 4, at the calyx or petal fall period on May 17 and in one instance at the second cover on June 10. Polybor was limited to the first or pre-pink spray except for Polybor alone which was applied at the pre-pink, pink and calyx.

Mildew counts (Podosphaera leucotricha), based on percentage of mildewed terminals, were made at seven spaced intervals including one pre-spray count. At the last count herein reported the individual trees were also classified as to severity of infection, using five classes based on descending severity of infection from class 1 (severe) to 5 (light)[6]. The corrected loss obtained by dividing the mildew percentage by the factor is shown in the table in the third column from the right.

While there were some indications that Polybor reduced the potency of the alkaline sulfur-containing materials at the time of the April 28 count, this deficiency was slight and the retardation only temporary. Since the rate of Polybor used in the trials was 1 pound per 100 gallons or double that recommended[7], it is even less of a possibility that any evident depressing effect on control is likely to be important. In addition, no injury to leaves or fruits was noted in the tests except where copper was applied. In this case injury was equal in the copper-sprayed trees whether or not Polybor was added. Copper in any form is unsafe on most fruit trees in the Wenatchee area. Apparently the addition of Polybor will not prevent copper russeting here.

A later spray applied July 14 combined 5 pounds of nutrient urea (NuGreen) plus 1 pound of Polybor. There was some leaf injury here. The combination had only slight fungicidal value, if any. Polybor alone applied three times (see Table) did not result in injury to the trees. It appears to be weakly fungistatic.

While these results are based on a single season's results, they do fairly well indicate that Polybor can be added at the pre-pink to any of the following materials without appreciably decreasing the efficiency of these mildew sprays: liquid lime-sulfur, Karathane, Polysulfide Compound, and Orthorix.

STATE COLLEGE OF WASHINGTON, TREE FRUIT EXPERIMENT STATION, WENATCHEE, WASHINGTON

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[1] Washington Agricultural Experiment Stations Project No. 1164.

[2] Plant Pathologist, State College of Washington, Tree Fruit Experiment Station, Wenatchee, Washington.

[3] Benson, N. R. 1953. Boron deficiency and excess. Western Fruit Grower 7 (10): 26-27. Oct.

[4] Anon. 1955. 1955 spray recommendations for tree fruits in eastern Washington. Extension Bul. 419 (Rev.) Jan.

[5] Grant-in-aid No. 3454 furnished by Pacific Coast Borax Co. The writer thanks Dr. Nels R. Benson for negotiating the facilities for this phase of the project and for suggestions relating to application of the Polybor.

[6] For a discussion of this method cf. Sprague, R. 1953. Apple powdery mildew spray trials, 1953. Plant Dis. Reptr. 37: 601.

[7] Loc. cit. footnote 4.

Table 1. Results of hand spraying irrigated Black Jonathan apple trees (11-year-old) to control apple powdery mildew at the Tree Fruit Experiment Station, Wenatchee, Washington with standard fungicides containing sodium pentaborate in the schedule, 1955.

Treatments, rates and when applied	Av. % Mildew on:							Factor on	Corrected loss on	Change from	Relative control
	April 15	April 28	May 16	May 31	June 10	July 5	July 29	July. 29	July 29	April 15	
Lime-sulfur 3 gals. + 1 lb. Polybor at pre-pink; 2½ gals. lime-sulfur at pink; 3 lbs. sulfur at calyx	58.5	51.1	36.5	36.5	41.0	44.0	41.8	2.9	14.4	-37.1	Good +
Same as above but Polybor omitted	45.8	38.4	26.9	31.4	41.3	35.7	33.3	3.0	11.1	-34.7	Good +
Orthorix 2 qts. + 1 lb. Polybor at pre-pink; Orthorix only, 2 qts. at pink and calyx.	37.6	44.1	32.3	27.7	40.3	45.8	47.5	3.0	15.8	-21.8	Good
Same as above but Polybor omitted	48.8	45.8	39.4	40.6	43.0	44.0	45.0	2.9	15.5	-33.3	Good +
Karathane 1 lb. + Polybor 1 lb. at pre-pink; Karathane only, 1 lb. at pink, calyx	58.2	49.3	44.1	31.6	42.6	50.4	42.2	2.9	14.6	-43.6	Good +
Same as above plus Karathane at 2nd cover 1 lb., but Polybor omitted	44.3	42.3	28.2	32.6	40.8	37.4	29.1	3.9	7.5	-36.2	Excellent
Neutro Cop 53, 1 lb. + 1 lb. Polybor at pre-pink and repeated at pink	47.9	46.0	44.3	46.8	46.8	69.0	58.9	1.5	39.3	- 8.6	Poor
Neutro Cop only, 1 lb. at pre-pink and pink	47.9	49.3	43.0	49.5	—	66.9	60.2	1.5	40.1	- 7.8	Poor
Polybor only, 1 lb. at pre-pink, pink, calyx	50.5	52.7	50.5	54.5	—	66.4	55.9	1.2	46.6	- 3.9	Poor
Karathane ½ lb. + glyodin ½ pint + Polybor 1 lb. at pre-pink, omit Polybor at pink and calyx	50.1	43.5	46.3	43.7	—	53.9	—	—	—	—	
Same as above less Polybor	47.1	46.3	40.6	43.4	43.4	46.8	40.8	2.6	15.4	- 30.4	Good
Polysulfide 4 lbs. + Polybor 1 lb. at pre-pink; Polysulfide only, 3½ lbs. calyx	54.2	50.5	52.5	46.6	—	36.6	41.7	2.9	14.4	- 39.8	Good +
Same as above less Polybor	44.3	43.1	31.5	35.3	—	46.9	39.7	2.8	14.2	- 30.1	Good +
Unsprayed checks	51.4	53.0	54.1	60.4	—	59.0	67.6	1.04	56.7	+ 3.7	None
NuGreen 5 lbs. plus Polybor 1 lb. on July 14	—	—	—	—	—	57.7	52.0	1.3	40.0	—	Poor

A DISEASE OF FIG (FICUS CARICA L.)

Paul L. Lentz[1] and L. O. Weaver[2]

Fig trees are sometimes able to grow and produce fruit in the vicinity of Washington, D. C., but the severe winter weather often leaves them weakened and easily subject to disease. An example of this has recently been noted at Cheverly, Maryland, a short distance northeast of Washington. There a single fig tree, approximately 10 feet tall and apparently vigorous until this year, has extensive cankers on many branches and also shows a die-back of many branch tips. Many of the cankers are covered by a rather thin but conspicuous tan, felt-like fungus that has been determined as Rhinotrichum macrosporum Farl. This is a hyphomycete previously reputed to be weakly parasitic (Linder, 1942, p. 173). It is not restricted to canker areas, but is also prominent in the vicinity of leaf scars, at the bases of dead twigs, and often at the tips of twigs showing die-back. It is so conspicuous and abundant that it might easily be thought to have caused the disease.

A second fungus, Phomopsis cinerascens (Sacc.) Trav., is even more constantly associated with the cankers and die-back than R. macrosporum. Phomopsis is well known as a cause of die-back of various hosts. In addition, Weiss and O'Brien (1952, p. 748), on the basis of a considerable number of reports, have stated that P. cinerascens causes a branch and twig canker of figs in Europe. All evidence, and especially the presence of P. cinerascens as the only fungus associated with many of the developing cankers, indicates that the present disease is caused by P. cinerascens. A third fungus found on the fig branches is Sphaeropsis malorum Pk. This is also a well-known disease-causing fungus, but it is much less abundant on the fig branches than the other two.

In addition to determination of pathogenicity, new host and geographical records and some unusual mycological aspects are involved in the consideration of these fungi. Both alpha and beta conidia of P. cinerascens (Fig. 1, C) are present and correspond closely with descriptions given for this species by Saccardo (1879, p. 521) and by Grove (1935, pp. 186-187). Weiss and O'Brien (l.c.) have listed this species on fig in California. In addition, Wehmeyer (1933, p. 76) has reported that Diaporthe eres Nit., reputedly the ascomycetous stage of P. cinerascens, has been found on fig in New Jersey. The present report represents a new geographical record at least for the Phomopsis stage, and also constitutes one of exceedingly few records of this fungus on fig in the United States.

Sphaeropsis malorum (Fig. 1, A) is the conidial stage of Physalospora obtusa (Schw.) Cke. The latter stage has been found on fig in Alabama and Florida (Weiss and O'Brien, l.c.). The conidial stage apparently has not previously been found on fig, although it is common on many hosts.

Rhinotrichum macrosporum (Fig. 1, B) is in some ways the most interesting of the three fungi. It has very large conidia and distinctive hyphae. The present specimen is unusual in having fewer and less densely grouped "sporogenous teeth" (terminology of Linder, l.c.) than is usual in this species. In other respects it is identical with more nearly typical specimens of this singular species. According to Linder (l.c.), this is one of the few species of Rhinotrichum "that appears to be weakly parasitic." He has cited Shear (1931, p. 22) and Walker (1930, p. 26) to support his assertion. Shear, however, reported that the fungus is probably saprophytic on cranberry leaves. Walker stated that it may cause a rot of cotton bolls that have previously been attacked by more vigorous "parasites." The whole context of Walker's statement leaves some doubt that he intended to imply any true parasitism for R. macrosporum. The present record is of interest primarily as a first report of this relatively uncommon fungus on fig and also as a depiction of its slightly aberrant anatomy.

In summary, this disease of fig seems to have been caused by P. cinerascens, and then R. macrosporum and S. malorum have apparently developed on the dead and dying branches.

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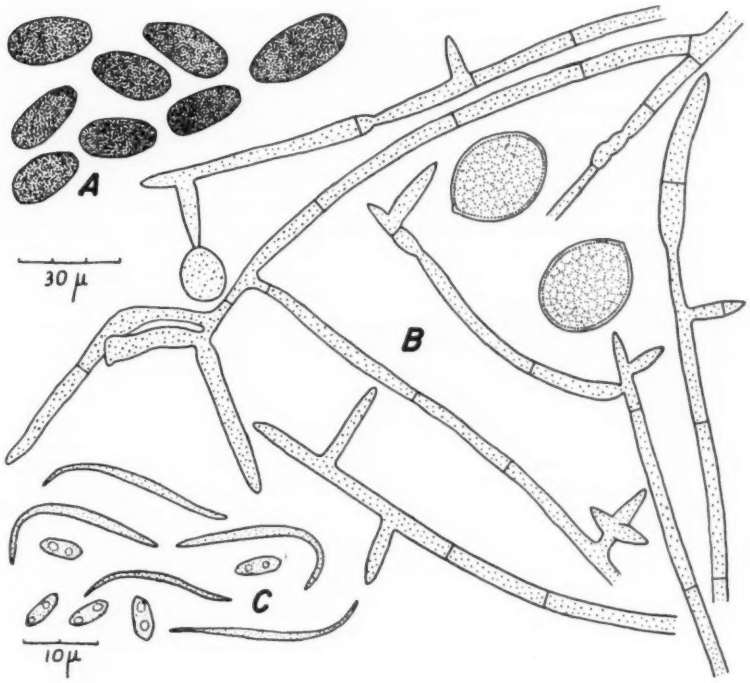

FIGURE 1. A -- Conidia of Sphaeropsis malorum. B -- Hyphae and conidia of Rhinotrichum macrosporum. C -- Alpha and beta conidia of Phomopsis cinerascens.

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NATIONAL FUNGUS COLLECTIONS, AND THE UNIVERSITY OF MARYLAND

ACTI-DIONE SPRAYS ON CANTALOUP[1]

Robert B. Marlatt[2]

In order to determine the effects of Acti-dione on cantaloups, three concentrations of the material (Upjohn Company tablets) were applied to potted PMR45 cantaloup plants five times during a 30-day period. Seeds were planted March 1 and plants sprayed at the two-leaf stage on March 22, 1955 and again March 28, March 31, April 13, and April 22. Four plants were sprayed with each concentration until the liquid began to drip from the foliage.

Sprays were made from the 4.88 gram (average) tablets, each of which was claimed to provide 1 ppm when dissoved in 100 gallons of water. Weights of tables varied from 4.791 to 4.952 grams. Tablets were ground in a mortar and the resultant powder was used to make up aqueous solutions of 1, 2, and 4 ppm. One ml. of duPont Spreader-Sticker was added to each gallon of solution and the control immediately before spraying.

The total length of each vine was recorded May 23, and vine length, number of lateral shoots, and percentages of leaves dead on the main runners were recorded June 15, 1955. There were no statistically significant differences, as shown by Table 1.

Table 1. Effect of Acti-dione on cantaloup vines.

Concentration	Average vine length in inches	Average number of lateral runners	Average percentage of dead leaves on main runners
1 ppm	42.3	5.5	46.7*
2 ppm	41.5	5.0	54.7
4 ppm	35.5	5.0	51.7
Control	32.5	4.5	48.2

* Differences are not statiscally significant.

It was interesting to note that there was no apparent phytotoxicity even at the 4 ppm strength. The vines were not stunted, the number of lateral runners was not decreased, and there were no more dead leaves on the sprayed vines than on the controls.

UNIVERSITY OF ARIZONA AGRICULTURAL EXPERIMENT STATION; MESA

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SPONGOSPORA SUBTERRANEA CANNOT THRIVE IN BRAZIL[1]

Josué Augusto Deslandes[2]

The Brazilian law of plant quarantine is very strict in relation to Spongospora subterranea (Wallroth) Johnson and other foreign pathogens of potatoes. Besides the regular health certificate for the importation of potatoes, a special paper is required attesting that the shipment is not only free from S. subterranea but also that it comes from a locality where this fungus is not found. No tolerance has been allowed up to now. Any trace of the fungus was enough for the rejection of the import. Thousands of tons of imported seed potatoes have been destroyed at our customhouses during the last 20 years.

Research men in several countries have demonstrated that S. subterranea depends on high moisture and low temperature acting simultaneously. In his experiments Ramsey[3] observed infection only in wet soil at 13.9° C with air temperature of 15.6°. Plants grown in wet soil at 17.2°were not infected. This restricted combination confines the fungus to specific regions of the world and conditions its outbreaks. In most of the Brazilian potato areas these two limiting factors do not occur together. As a matter of fact Spongospora has not been found in these areas. The author works with potatoes in southern Brazil and for years has inspected potato fields in six States. It is easy to find common scab (Streptomyces), but not a case of powdery scab.

Brazilian plant quarantine inspectors are so remarkably expert in detecting Spongospora on imported potatoes as to cause disappointment to complaining exporters. Even so, this fungus may have had chances to escape the inspection, especially in the case of tubers with light traces of nontypical lesions. At least once in 1947 this possibility was proved true. Infected French seed potatoes passed the inspection and were planted in several experimental stations of four States. Examination of the progeny of those infected tubers grown at three stations did not show any lesions of powdery scab.

In the extreme south, at about 31.5° south latitude, there is an important potato region where two crops are grown every year. The weather and soil conditions prevailing during the fall crop were supposed to fit the requirements of Spongospora. Nevertheless, the fungus did not show up in any of the experimental plots the writer has harvested, nor in fields he has inspected and bins he has examined. Not even during a special survey he made in two of the principal potato counties was it found.

From 1948 to 1950 mycological studies and tests were made under the most favorable conditions for a myxomycete.

In ten different tests a total of 168 imported tubers, with medium to severe powdery scab, were planted in moist cool soil. Roots and 449 tubers were examined at harvesting time and not a single pustule of Spongospora was seen. A few lesions on 15 tubers, without spore balls, were attributed to common scab. The next series of tests proved that at least a few spore balls on imported tubers were viable.

In 15 tests the young sprouts of 124 tubers were inoculated with a heavy suspension of spore balls. About 100 spore balls were applied on each tuber with a fine brush. A total of 615 tubers were harvested. Twenty-three of the tubers and 15 roots had a few lesions of Spongospora.

The tests were discontinued because of the negative results of the last inoculations and failure to increase the inoculum.

Only in 1955 were new infected potatoes made available. This time 421 crates of imported seed with a light infection by Spongospora were planted in three isolated fields of about 6.5 hectares and in four small experimental plots. Seed for these small plots was chosen from among tubers showing more powdery scab. Environment of plots and fields was probably the best Spongospora could find in Brazil. Thirty-six German and Dutch varieties were represented.

As for the fall crop, the planting was made in February, when, as normal in the area, soil and air temperatures are high, soil humidity is low, and evaporation high. It is only during April that weather becomes more favorable to Spongospora. Except for years with a short

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[1] This is a cooperative work of the Instituto Agronômico do Sul and the Divisão de Defesa Sanitaria Vegetal, Ministério da Agricultura.

[2] Plant Pathologist, Instituto Agronômico do Sul, Pelotas, Rio Grande do Sul, Brasil.

[3] Ramsey, G. B. 1928. Influence of moisture and temperature upon infection by Spongospora subterranea. Phytopath. 8:29-31.

"Indian summer" in May, this month is the best time for Spongospora in the region, as far as soil and air moisture and temperature are concerned. However, harvesting starts by the middle of May, leaving little opportunity for the organism.

The following data of the Section of Climatology, Instituto Agronômico do Sul, indicate the fall environment of the Pelotas region.

	Jan.	Feb.	Mar.	Apr.	May	June
Average air temperature for 55 years, °C	23.2	23.4	22.0	19.1	15.9	13.4
Average soil temperature, °C, at a depth of 20 cms., in 1955	29.1	26.6	23.9	20.6	15.9	12.9
Average evaporation, in millimeters, in 1955	190.7	102.1	98.9	95.4	85.4	56.0

The conclusion is that there is no environment that favors Spongospora subterranea in Brazil. Even in the southernmost part of the country and even under irrigation there is no reason to fear this slime mold. The recent decision of the Brazilian plant quarantine to allow a certain degree of tolerance for Spongospora subterranea in imported seed potatoes is a safe and logical one.

INSTITUTO AGRONÔMICO DO SUL AND THE DIVISÃO DE DEFESA SANITARIA VEGETAL, MINISTÉRIO DA AGRICULTURA, PELOTAS, RIO GRANDE DO SUL, BRASIL

BROWN STELE OF LETTUCE

Robert B. Marlatt[1]

Summary

A head-lettuce disease has been found in Arizona which causes the stele of the tap-root to assume a brown color. When severely diseased, the root pith becomes hollow and secondary decay may result in a black discoloration.

Four bacterial cultures, obtained from roots of diseased plants, failed to cause the disease when soil was inoculated with the organisms before and after planting.

A significantly greater amount of the disease was found in field plots which had received 40 tons of manure per acre than in control plots or in those which received 185 lbs. of calcium nitrate per acre.

A disease of head lettuce was found in the Yuma Valley of Arizona in 1952, and later in the Salt River Valley in 1953-1955, which had not been previously reported in the State.

Plants affected by the disease exhibited a slight wilting and a grayish-green color, symptoms of a shortage of water. During the cooler evenings, plants revived and as cooler weather arrived during October, above-ground symptoms disappeared. The yields from affected fields were not noticeably lowered.

Table 1. Effect of calcium nitrate and manure on brown stele on lettuce.

Treatment	Severity rating of damage to tap roots[a] Replicates						Average
	1	2	3	4	5	6	
185 lbs. calcium nitrate per acre	.68	.83	.80	.46	.46	.23	.576
40 tons manure per acre	1.44	1.45	1.56	1.76	.89	1.60	1.450
Control no. 1	1.04	.13	.73	.79	.04	.42	.525
Control no. 2	0	.36	.35	.33	.17	1.81	.503
L.S.D. 1%							0.73

[a] Rated on basis of 0 = normal to 3 = severely diseased.

When tap-roots of diseased plants were split longitudinally, the steles were seen to be distinctly discolored, reddish-brown or dark brown, and frequently were hollow. The discolored or hollow area did not extend into the head but often it could be traced down the entire length of the tap-root.

A similar malady has been described by Thomas (1) and by Mix (2).

Organisms Associated: No fungi could be found in the discolored area but darkened gum or latex was seen to fill the xylem tissues. Bacteria were present in all roots examined and four bacterial cultures which were obtained from roots of diseased plants were tested for pathogenicity.

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Arizona Agricultural Experiment Station Technical Paper No. 373.

Great Lakes lettuce was grown in flats and transplanted to pots of sterilized soil, one plant per pot. After the transplants had become established, a nutrient broth culture of each of the four bacteria was used to inoculate the soil of 14 pots. Fourteen control pots received sterile nutrient broth. The pots were twice again inoculated at 2-week intervals.

Four months after transplanting, each plant was split longitudinally through the head, stem, and tap root and examined. None of the 70 plants showed discoloration of the tap root.

Effect of Manure: In 1955 a Horticulture Department lettuce experiment was observed for brown stele symptoms. An average of 21 heads were examined in each of 24 field plots which consisted of two fertilizer treatments and two controls. Some plots received calcium nitrate equivalent to 185 pounds per acre, others received steer manure at a rate of 40 tons per acre, and controls received no fertilizer. These treatments were each replicated six times and randomized.

When the heads were ready for harvest, tap roots were split and rated as 0 = normal to 3 = severely diseased. The totals of the ratings were divided by the number of heads examined per plot and the resulting figures compared.

Table 1 points out that there was a significantly greater amount of root damage in plants from the heavily manured plots.

Additional isolations and pathogenicity tests are to be carried on in an attempt to find the cause of the lettuce stele decay. The role that manure plays in increasing the severity of the disorder is as yet undetermined.

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CONTROLLING MUSHROOM DISEASES WITH CHLORINATED WATER

T. T. Ayers and E. B. Lambert

Summary

Experiments have shown that bacterial blotch, soft rot of pinheads, Verticillium spot, and Mycogone diseases of mushrooms may be controlled by chlorinating the water used for wetting the beds. The recommended strength is 50 to 200 ppm of available chlorine. The first application should be delayed until the mushrooms begin to appear on the beds. When this procedure is followed, several diseases are materially reduced with no detrimental effect on the yield or quality of the mushrooms and no health hazard to consumers or men working in the mushroom houses.

INTRODUCTION

Chlorinated water has been used for many years for disinfecting mushroom casing soil and as a fungicide and bactericide in and around mushroom houses. For at least 25 years mushroom growers in central France have been using a solution of sodium hypochlorite (Javel water) for sterilizing casing soil (2). It also has been an accepted practice for growers both in Europe and in the United States to make local applications of hypochlorite powder or strong hypochlorite solutions to eradicate outbreaks of the mildew and bacterial blotch diseases of mushrooms (3, 5, 7). Until quite recently, however, it has been assumed that chlorinated water would be harmful if applied to producing mushroom beds in solutions strong enough to control disease organisms. The first indication that this might be a false assumption came from the experiments described by Bulloch in 1950 (4). In these experiments he was able to control Acremonium sp. with a hypochlorite solution, which he pointed out caused "hardly any discoloration" of the mushroom tissue.

The studies described here were made to explore systematically the feasibility of controlling several soil-borne disease organisms by watering the beds with chlorinated water during the entire cropping period.

In the winter of 1952, we reported[1] the results of our first season's tests on the control of blotch disease and also urged a few growers in eastern Pennsylvania to test chlorinated water in commercial houses. The favorable results obtained in our experiments and in tests made in commercial houses have led to the extensive use of chlorinated water in the past 2 years as a part of the routine growing procedure in commercial houses in eastern Pennsylvania and Delaware. The purpose of this paper is to describe the results of our experiments, outline the experience of commercial growers and discuss the advantages and limitations of using chlorinated water in commercial practice.

EXPERIMENTAL PROCEDURE

Most of the experiments consisted of applying chlorinated water of different strengths to trays which had been previously sprayed with inoculum from cultures of the different pathogens and to other trays prepared for yield tests. The water was chlorinated by dissolving BK powder or mixing solutions of sodium hypochlorite in water to bring the concentration of available chlorine to the desired number of parts per million. The solutions we used were made up in accordance with the manufacturer's directions. The concentration of chlorine was checked by the "Ortho Tolidine" method. "LaMotte Chlorine Test Papers" were used for making rapid rough approximations of chlorine concentrations. They are expressed as "available chlorine" to conform with standard methods of examination of water and sewage (1). When these solutions were tested with the "Ortho Tolidine" method values of "active chlorine" were obtained which were one-half of the "available chlorine." This is an important point to bear in mind since a solution testing 200 ppm "active chlorine" with the Ortho Tolidine method would actually contain 400 ppm "available chlorine." The reason for this difference is clearly explained by Rudolph and Levine (6).

Chlorinated water was applied to the beds simply by substituting it for the tap water cus-

[1] Paper was given at the Potomac Section, American Phytopathological Society.

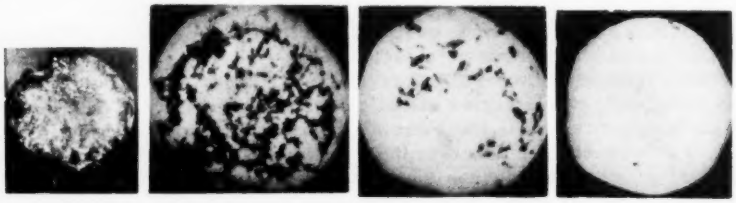
tomarily used for maintaining moisture in the casing soil.

Yield tests were made in trays arranged in a randomized block design. Each tray contained 3 1/2 square feet of surface. There were 6 randomized blocks with from 5 to 12 treatments in each block depending on the experiment. In filling the trays sufficient compost to fill all of the trays in each block was removed from the main heap and mixed thoroughly before filling to insure that the compost in every tray was as nearly alike as possible. The recorded yields are the weights of pulled mushrooms less 20 percent to account for the stubs that are normally trimmed off.

To insure a plentiful supply of the different diseases several groups of six boxes were sprayed with spore suspensions of different pathogens. The following organisms were used: Pseudomonas tolaasii Paine, Verticillium sp., Mycogone perniciosa Magn., Dactylium dendroides Fr., and Geotrichum sp. The bacterial blotch organism was applied after the mushrooms developed on the bed. All other organisms were applied to the soil either before casing or immediately after casing.

DISEASE CONTROL EXPERIMENTS

Bacterial Blotch Disease: Our first experiments were made in 1951 to test the control of bacterial blotch by concentrations of available chlorine similar to those used to control bacteria in the dairy industry. A high incidence of the disease was obtained on 24 trays by spraying with a bacterial suspension and by maintaining a high humidity in the air with live steam. Before the treatment was applied nearly two-thirds of the mushrooms were blemished. Chlorine solutions were applied in strengths of 33, 100, and 200 ppm of available chlorine. The diseased condition gradually disappeared with successive waterings until after several waterings the classes of disease severity were distributed as indicated in Table 1. The manner in which the disease was cleared up suggested that it was being controlled by eliminating the blotch organism in the soil rather than by protecting the surface of the mushroom caps. In making up Table 1 four classes of infection are indicated. Examples of these are shown in Figure 1. It is evident that blotch may be effectively cleared up with chlorinated water even though the incidence of disease before treatment is much more severe than ordinarily encountered in commercial houses. Subsequent



Severe Moderate Light None

FIGURE 1. Mushroom caps with bacterial blotch typical of the infection classes indicated in Table 1.

Table 1. Controlling bacterial blotch with different levels of available chlorine.

Level of chlorine	Caps examined no.	Classes of cap discoloration			
		Severe %	Moderate %	Light %	None %
Control	1064	34	17	15	34
33 ppm	963	4	6	11	78
100 ppm	939	1	2	6	90
200 ppm	791	1	1	5	93

experience has corroborated this conclusion.

Soft Rot of Pinhead Mushrooms: After each flush of mushrooms is picked off, many of the remaining small mushrooms (pinheads) die. This dying of pinheads is due to the breaking of their channels for food translocation in the soil during picking and is inevitable. The presence of these numerous dying mushrooms on the bed poses a problem in sanitation. They are usually removed by careful hand picking. If they are not removed they may become putrid from bacterial soft rot and reduce the subsequent yield of healthy mushrooms in the affected area.

When the beds are watered with chlorinated water the dead pinheads shrink to wrinkled mummies without rotting. In this condition they are harmless and need not be removed by laborious hand picking.

Pit Disease: We have not been successful in our efforts to reproduce typical "Pit" symptoms uncomplicated by blotch disease symptoms by spraying the beds with bacterial cultures. Woods (9, 10), who has perhaps done more work with this disease than anyone else, described similar results as follows: "Under experimental inoculation conditions it has not yet been possible to induce an effect where, instead of Bacterial Rot symptoms supervening, the effect of the soft rot bacteria attack is to cause localized rotting areas, viz., 'pitting'".

In view of the difficulties encountered in experimentally reproducing the pit disease, it is necessary to rely on evidence of control obtained in growers' houses where the incidence of typical pit disease has been rather high. Several growers have informed the writers that pit disease has been reduced or eliminated in their houses through the use of chlorinated water. The experience of a grower in Miami, Florida, may be cited as an example. One of the authors visited this plant in February 1953. Typical pit disease was prevalent at that time and was largely uncomplicated by bacterial blotch. It was estimated that nearly 50 percent of the mushrooms were pitted. The application of chlorinated water (100 ppm) was suggested as an experimental control measure. About 3 weeks later this grower reported that the "pits" were reduced to less than 5 percent of the mushrooms on the bed.

Verticillium Disease: Six trays were incoulated with a spore suspension shortly after casing time. Beginning on the same day, three of the trays received water with no chlorine and three a solution with 100 ppm available chlorine. A few spotted mushrooms appeared in the non-treated trays during the second flush. In successive flushes the percentage of spotted mushrooms increased and some of the mushrooms became deformed. Infection became so heavy that in later flushes at least half of the mushrooms were spotted (Figure 2). Most of these spotted mushrooms were unsalable. None of the mushrooms in the treated trays were spotted until

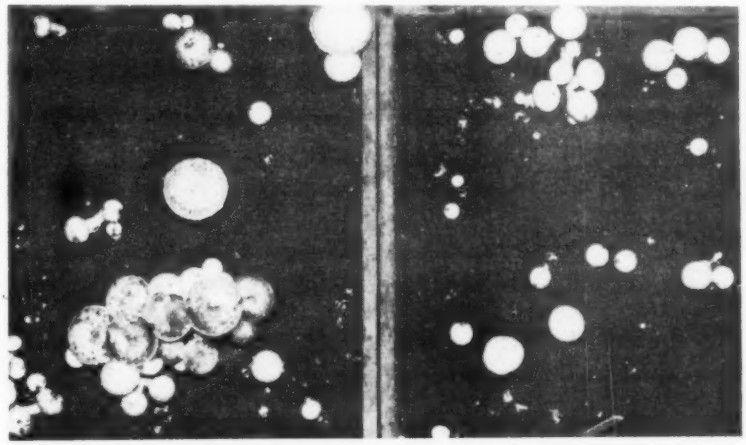


FIGURE 2. Verticllium spot disease on untreated (left) and treated (right) trays of mushrooms.

the later flushes when a few mushrooms appeared to be spotted from water splashing from nearby untreated trays. The control was clear-cut and decisive. Furthermore, production in the untreated trays practically ceased after 4 or 5 breaks as the result of infection and stunting of the young mushrooms by the Verticillium mycelium in the soil. In contrast, the treated trays continued to produce clean, normal, healthy mushrooms.

Mycogone Disease (Bubbles): Experiments were made on the control of the bubbles disease similar to those outlined for the Verticillium disease. Here, again, the trays were inoculated with a suspension of Mycogone spores shortly after casing and the treatment with chlorinated water was begun immediately. The infestation was so successful that after three breaks more than half the mushrooms of the untreated trays were parasitized and partially or wholly deformed by Mycogone fungus. The amount of disease in untreated trays is shown in Figure 3. No "bubbles" appeared during the first 4 or 5 breaks in the treated trays. A few "bubbles" appeared in these trays at the end of the crop, but at that time the surface of the beds dried more

FIGURE 3. Severity of bubbles disease in control trays.

slowly and we were not watering oftener than once in a week or 10 days. It is our opinion that these "bubbles" were caused by spreading the fungus from the untreated trays as a result of picking and trashing between waterings.

After the untreated trays became covered with "bubbles", an attempt was made to eradicate the infection in two of the trays by applying chlorinated water (100 ppm). The relative percentage of "bubbles" to clean mushrooms was considerably reduced but we did not succeed in bringing these trays back to a disease-free condition similar to that of the treated trays. We attributed our failure to the fact that the soil was rather moist at the time we started using chlorinated water and in all probability the chlorine was highly diluted by the water already present in the soil.

In commercial growing it is not anticipated that chlorinated water will replace soil sterilization or control a well established infestation of bubbles. On the other hand, if used early enough and consistently throughout the crop it should significantly delay the appearance of a heavy infestation in a manner similar to that attained from the use of zineb.

Mildew Disease: Probably because of a low humidity in the house early in the spring, this disease did not appear, in spite of our inoculations, until about the sixth break. Our tests were inconsistent and inconclusive but suggest that 100 ppm available chlorine will not eliminate mildew. Stronger solutions were not tried.

Acremonium Disease: This disease has not yet been recognized in the United States. Bulloch (4) described its control in England with 0.1% solution of sodium hypochlorite. From the results of his experiments it seems probable that the Acremonium disease is fully as amenable to control with chlorinated water as the Verticillium spot disease which it so closely resembles in symptoms.

Lipstick Disease: During the past 2 years we have watered most of the trays in our pilot plant with water containing 100 ppm available chlorine. In spite of this treatment Geotrichum sp. has appeared in our growing rooms before the end of each crop and in some trays fully invaded the soil. There was some suggestion that chlorinated water may have slightly reduced the rate of spread of Geotrichum but it clearly was not effective enough to be considered a satisfactory control measure.

Other Diseases: Evidence is as yet lacking on the effect of chlorinated water in controlling soil-inhabiting organisms such as: Fusarium sp., Myceliophthora sp., Trichoderma sp., Oedocephalum sp., Botrytis sp., and the unknown organism causing Mummy disease.

EXPERIENCE OF COMMERCIAL GROWERS

As mentioned previously, several commercial growers were asked about 3 years ago to test chlorinated water on an experimental basis. On the basis of the experience gained in these tests many growers in the eastern Pennsylvania and Delaware mushroom-growing area are now using chlorinated water exclusively. A consensus of these growers would seem to be that chlorinated water helps them to prolong the harvest of clean mushrooms and delays the appearance of diseases. The cost for the materials is comparatively low and is not considered to be a serious limitation.

EFFECT ON APPEARANCE AND FLAVOR

After learning that chlorinated water would control disease, we were confronted with the question of how this procedure would affect quality and yields. Experiments soon showed that water chlorinated to 100 or 200 ppm has no detrimental effect on the appearance of the white variety of mushrooms on the beds. On the other hand, tests with increasing amounts of chlorine in the water indicate that excessive chlorination will cause a yellowing of the surface of the mushrooms in 1 or 2 hours after the water has been applied. The minimum concentration causing discoloration is about 300 ppm of available chlorine. The margin of safety between the 100 ppm available chlorine used for disease control and the concentration at which tanning begins is apparently sufficient for practical purposes in commercial culture. Mild yellowing is not serious and growers often determine the chlorine concentration they want to use by increasing the concentration until slight discoloring occurs, then "backing off" to a safe concentration. In experiments where the available chlorine was carefully checked we have never seen yellowing caused by 200 ppm or less.

We have been cooking and eating "white" mushroom from our experimental beds, with and without treatment, for 4 years, and have never noticed any off-color or off-flavor in cooked mushrooms that had been treated at the rate of 100 ppm. During the past 3 years, thousands of pounds of the "white variety" of mushrooms have been picked from commercial beds treated with chlorinated water and subsequently sold on the fresh market or to canners who process in salt brine. We do not know of a single complaint from the purchaser of these mushrooms. Also, careful comparative tests made by the Quality Control Department of the Brandywine Mushroom Company have shown clearly that mushrooms from beds treated with chlorinated water do not have an off-flavor or off-color when processed in the usual brine pack.

We have not watered beds of the "brown" variety with chlorinated water but understand from the experience of others that this variety reacts somewhat differently than the whites. The Grocery Store Products Company, West Chester, Pennsylvania, grows the brown variety exclusively on a very large scale and processes them into a product known as "Broiled in Butter." Mr. J. C. Bovenkirk, their Director of Research wrote us regarding the Company's experience with browns as follows:

> "I have noted that the cream pigmentation has a yellow cast immediately after the chlorine water is applied, however, it is only a temporary effect. The mushroom regains its usual color in a few hours. -- We ran an entire crop using 100 ppm chlorine water on 30 houses. We used only chlorine water. The appearance of the mushrooms was normal in color, shape and size after processing. We have received no complaints from consumers on 'off-flavor' or lack of flavor. Our Quality Control Department which checks daily the canned pack found the chlorine treated to be the same in every respect as the untreated."

The most discouraging news regarding the effect of chlorinated water on quality is the experience of the Butler County Mushroom Farm that grows mushrooms extensively in caverns and prefers a cream variety sometimes called the "golden white." In correspondence, J. W. Sinden described the results of a cooking test as follows:

> "The color was not noticeable on the exterior of the mushrooms, but when they were cut and cooked they became light yellow, while the odor and flavor of the cooked

mushrooms was suggestive of chlorine."

EFFECT ON YIELD

Observations and experiments indicate that chlorinated water has no detrimental effect on yields when it is applied at the time of the first "flush" of mushrooms or thereafter. Occasionally, however, when beds are watered early with chlorinated water, there is a yield reduction of 10 or 15 percent, similar to that which we have sometimes noted when zineb is drenched into the soil at casing time.

The results of an experiment designed to test the effect on the yield of mushrooms of calcium hypochlorite vs. sodium hypochlorite, low chlorine vs. high chlorine, and early application vs. late application, are shown in Table 2. The yields shown in the table are the means from 6 replicate trays prepared as described in the discussion of experimental methods. An

Table 2. The effect on mushroom yields of different times of application and levels of calcium hypochlorite and sodium hypochlorite in solution.

Chemical	Available chlorine ppm	Yields in pounds per square foot when first applied at	
		Casing	1st Flush
Calcium hypochlorite	100	3.6	3.9
	200	3.3	3.8
Sodium hypochlorite	100	3.5	3.9
	200	3.2	3.8
Control	None	3.8	
L.S.D. 1%: 0.3 5%: 0.2			

analysis of variance indicates that the reduction in yield due to early application (at casing time) and high level of chlorine (200 ppm) are highly significant but the effects of the sodium vs. calcium salts of hypochlorite and the interactions are not significant.

We are inclined to explain the yield reduction from early application on the basis of an hypothesis that chlorinated water is slightly toxic to growing mushroom mycelium but not to the mushroom caps or to the thick strands which form in the soil just previous to fruiting.

For practical purposes, all that is necessary to insure against yield reduction seems to be to avoid excessive chlorination and to delay adding hypochlorite to the water until the first mushrooms appear. Since first "flushes" are usually comparatively free from disease, this delay should not affect the disease control program.

HEALTH HAZARDS FROM THE USE OF CHLORINATED WATER

Two questions are frequently asked regarding the risks from using chlorinated water: Is there a possibility of harm from human consumption of treated mushrooms? Will workmen be adversely affected by chlorine gas emerging from treated soils?

Inquiries made in the U. S. Public Health Service and the Food and Drug Administration indicate that there can be no harmful effects on the consumer from applying chlorinated water to mushrooms. For this reason no restrictions are anticipated.

The question of the hazard to workmen in the mushroom houses was raised with the Pennsylvania Bureau of Industrial Hygiene. Tests were made by this agency in commercial mushroom houses to determine the concentration of chlorine in the air shortly after chlorinated water has been applied to the beds. W. H. Taylor (8) summarized the results of these tests as follows: "Atmospheric samples taken during the wetting of the mushroom beds, (with chlorinated water)

and again 20 minutes after, failed to reveal any trace amounts of chlorine in any of the work atmospheres tested. It is not believed that the practice of using the chlorinated water on the mushroom beds will present any health hazard from the standpoint of inhalation of chlorine gas."

It may be of interest to note here that the inhalation and assimilation of traces of chlorine gas on successive days is not an accumulative process analogous to that of lead poisoning or silicosis. Therefore, repeated exposure would not constitute a special hazard.

METHODS OF PREPARING AND APPLYING CHLORINATED WATER

In large cities water is chlorinated by metering chlorine directly into the water mains from cylinders of liquid chlorine. Because of the danger of handling pure chlorine gas and the high cost of the chlorinators, it probably will not be feasible for most mushroom growers to install this type of equipment.

The most feasible method of chlorination would seem to be simply the addition of calcium hypochlorite (bleaching powder) or sodium hypochlorite to the water in a large tank or a 50-gallon drum. This method is widely employed in small municipalities for treating drinking water; also for chlorinating water used in small swimming pools, and for disinfecting utensils in dairies and food processing establishments. Stabilized hypochlorites are especially packaged for this purpose under several proprietary names in containers varying in size from 1-pound to 100-pound drums. Directions usually are given on the package label for making up concentrations on available chlorine in the range desired. Each grower must choose for himself whether his requirements can best be met by making up the desired strength of solution in large tanks and pumping it directly into the watering line or by making up a concentrated solution and metering it into the water line to obtain the required strength. In any case the water applied to beds should be tested occasionally to make sure the solution is the desired strength (usually 100 ppm). Chlorine test papers are available which provide an inexpensive, rapid and convenient means of making approximate determinations in this range. If the practice of using chlorinated water should become widespread, spawn makers and dealers in mushroom supplies will no doubt soon be in a position to furnish the necessary supplies or furnish the names and addresses of dealers in these supplies.

DISCUSSION

In our opinion the experiments described above and the experience of many mushroom growers justify recommending extensive trials with chlorinated water in commercial mushroom houses. Of course in the long run each grower must decide for himself whether, under his growing conditions, the gain from using chlorinated water outweighs the trouble and expense of applying it. It is not a "cure all" and cannot be expected to eliminate the need for sterilizing the soil or fumigating empty mushroom houses. To assure optimum results the concentration of available chlorine should be held within the recommended limits (50 to 200 ppm) and the solution should not be applied until after the mushrooms begin to form on the bed.

When these requirements are met chlorinated water has several points in its favor as a disease control agent: 1) It is effective both as a bactericide and a fungicide, yet does not discolor the mushrooms, affect their flavor, or reduce yields; 2) It leaves no residue on the mushrooms toxic to the consumer, 3) It leaves no toxic residue in the soil; 4) There is no health hazard to the workmen applying it; 5) It retards the organisms causing bacterial blotch, soft rot of pinheads, Verticillium disease, bubbles disease, and bacterial pit. The combined net result is to delay the appearance of significant numbers of diseased mushrooms on the bed. This increases the number of flushes during which most of the crop consists of top grade, unblemished mushrooms.

Chlorinated water and zineb are about equally effective in controlling Verticillium and Mycogone. Therefore, the question is frequently raised as to whether dusting with zineb can be discontinued when using chlorinated water. In our opinion dusting with zineb can probably be safely omitted in the average house during the winter months. But in damp caves and in mushroom houses in the late spring, it probably will be advantageous to apply both zineb and chlorinated water.

The principal limitation of chlorinated water lies in the fact that it is decidedly less effective under damp conditions when the moisture content of the soil is high and very little water is required. Under these circumstances the high water content of the soil may dilute the level of available chlorine to a point below the minimum for effective disease control.

An excellent review of the literature on chlorination of drinking water and detailed studies of the factors affecting the germicidal efficiency of hypochlorite solutions may be found in the paper of Rudolph and Levine (6).

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HORTICULTURAL CROPS RESEARCH BRANCH, AGRICULTURAL RESEARCH SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE

MAGNESIUM IN MUSHROOM CASING SOIL

E. B. Lambert and T. T. Ayers

Most mushroom growers in the United States use limestone to neutralize the acid soil generally employed to case or top-layer the mushroom beds. Commercial ground limestone may vary in its content of magnesium carbonate from 1 to 45 percent. This lact of uniformity in limestone has raised the question of the possibility of a yield reduction due to the toxic effect of a high magnesian limestone.

Sinden and Kligman have expressed somewhat different views on this question. Sinden is apprehensive of a high magnesium content in casing soils and has been credited with stating, "Soils of high magnesium content when used for casing mushroom beds delay production of the crop and may reduce total yields by half. The exact limits of this effect have not been determined. Use of high-magnesium lime for adjusting the acidity of casing soil should be limited to soils which are naturally low in magnesium. Several cases of severe injury to mushroom beds have been reported where this precaution was not observed." (1).

Kligman (2), on the other hand, believes there is little risk from neutralizing casing soil with limestone high in magnesium carbonate and stated, "Although magnesium is a toxic element in high amounts, the quantity incorporated in the soil for liming purposes is insufficent to cause an injurious effect. There is evidently no preference between pure limestone and one containing large amounts of magnesium carbonate."

In view of these differences of opinion and recommendations, the experiments discussed here were made to throw some additional light on the question of possible toxicity of magnesium in the casing soil. In these tests 10 different lots of Chester Loam casing soil were prepared by adding ground limestone from two different sources in amounts of 0, 2, 7, 10, and 20 percent of the moist weight of the soil. One of the limestones contained 33 percent magnesium carbonate and the other 1 percent. Trays cased with these soils were prepared for yield tests as previously described (3). The experiment was arranged in a randomized block design with 6 replicates.

The mean yields obtained from trays cased with different soil and limestone mixtures are shown in Table 1.

Table 1. Effect on mushroom yields of adding to the casing soil different amounts of limestone with high and low magnesium content.

Type of limestone	Yield in pounds per square foot with limestone added as follows:			
	2%	7%	10%	20%
High magnesium (33% magnesium carbonate)	4.1	3.9	4.0	3.8
Low magnesium (1% magnesium carbonate)	4.1	3.9	3.8	3.8

It is apparent that there was no difference in yield due to various amounts of magnesium in the limestone mixed with the soil. Also, the quality of the mushrooms did not change, nor was there any difference in the time of appearance of the first mushrooms on the trays. The fact that yields were not lowered after adding 20 percent of high magnesium limestone to the soil would seem to be especially significant, since limestone added at this rate supplies at least 10 times as much as normally would be required to neutralize casing soil.

The total magnesium oxide equivalent of the soil, after adding 20 percent of high magnesian limestone, was about 4 percent on a dry weight basis. This is approximately 3 percent more than most soils contain and about 1 percent more than soils with very exceptionally high magnesium content (4). Growers adding the usual 2 percent of limestone would be adding only about 0.6 percent of magnesium oxide equivalent to the dry weight of the soil even though the magnesium carbonate content of the limestone may be as high as 45 percent. This would raise the magnesium oxide equivalent of most top soils to less than 2.5 percent and of those few soils with

exceptionally high magnesium content to less than 3.5 percent. Both these levels are considerably lower than the 4 percent in one of the soil mixtures of our experiments. Moreover, it is probable that soils with exceptionally high magnesium content would not require neutralizing.

Our experiments lend support to Kligman's view that mushroom growers need not be concerned about the proportion of magnesium carbonate in limestone used for neutralizing casing soil that has been derived from the top 6 inches of a well developed profile.

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CRAZY TOP OF SOME WILD GRASSES AND THE OCCURRENCE OF THE SPORANGIAL STAGE OF THE PATHOGEN[1]

Arnold J. Ullstrup

Summary

Goose-grass, love-grass, and stink-grass are reported as new hosts for Sclerophthora macrospora (Sacc.) Thirum., Shaw & Naras. Sporangia developed sparsely only on the leaves of crabgrass in a moist chamber. Sporangia were found also on a corn plant severely affected by crazy top. Attempts to germinate the sporangia were unsuccessful. Efforts to induce infection in seedlings of the wild grasses by growing them in presumably "diseased" soil met with failure.

Goose-grass (Eleusine indica (L.) Gaertn.), love-grass (Eragrostis pectinacea (Michx.) Nees), stink-grass (Eragrostis cilianensis (All.) Link), green foxtail (Setaria viridis (L.) Beauv.), and crabgrass (Digitaria sanguinalis (L.) Scop.) were found with typical symptoms of crazy top. The disease has been reported previously on the two last named grasses (1, 5), but the other three appear to be new hosts. Sections of leaves and stems confirmed the presence of oospores similar in size, shape and color to those of Sclerophthora macrospora (Sacc.) Thirum., Shaw & Naras. = (Sclerospora macrospora Sacc.).

Infected plants were found in an area approximately 100 x 300 feet on the campus of Purdue University. The plot had been excavated to a depth of 3 to 4 feet 2 years before in preparation for construction. The top soil had been removed leaving the gravely subsoil exposed. The surface of the excavated area was uneven and numerous depressions provided for the formation of puddles where water stood for varying lengths of time. Infected plants were found on the margins of these puddles. This observation again confirms the apparent necessity of flooding or water-logging for the infection to take place.

Symptoms on goose-grass were most conspicuous. The barren heads were reduced to a thick, bunchy mass of proliferated bracts (Fig. 1A). Leaves and stems were shortened and often showed light green striations. Symptoms on green foxtail and stink-grass were characterized by malformation of the heads and in general were similar to those found on goose grass. Infected plants of love-grass and crabgrass produced heads infrequently. In these latter two species the conspicuous symptom was the bunched or cushion-like appearance (Fig. 2A) in contrast to the spreading of healthy plants (Fig. 2B). The bunchy condition was due, apparently, to marked shortening of the internodes. Leaves were much reduced in length and width. Another characteristic symptom on these two grasses was the fine, light green to yellowish mottling of the leaves. These minute pellucid dots when sectioned or cleared were found to be "nests" of oospores embedded in the tissue. The symptoms of crazy top on these wild grasses are, in general, quite similar to those found on corn affected by the same disease (1, 5).

Diseased plants of love-grass, goose-grass, stink grass, and crabgrass were transplanted to pots, brought to the greenhouse and, after establishment, placed in moist chambers to induce formation of sporangia on the surface of the leaves. After a 48-hour period, during which time the leaves were covered with a film of water, leaves and scrapings of leaves were examined for the presence of sporangia. Only on crabgrass were sporangia found, and then in sparing numbers. Sporangia were lemon-shaped, colorless to faintly greenish, granular, and resembled those of Phytophthora. They were borne on short, simple or 2- to 3-branched, sporangiophores issuing from the stomata. Attempts to germinate sporangia in water at 16°, 22°, and 30°C were unsuccessful. Efforts were made to induce infection in goose-grass, love-grass, and crabgrass by growing plants from seed of these grasses in soil taken from around the roots of diseased plants in the field. Pots in which plants were growing were flooded for periods of 24, 48, and 72 hours under cool (65° F) and warm (80° F) temperatures, and when seedlings were just emerging and when seedlings were 3 inches high. In no instance was there evidence that infection was established.

The Occurrence of Sporangia on Corn: A number of corn (Zea mays L.) plants infected

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[1] Journal Paper No. 907, Purdue University Agricultural Experiment Station, Lafayette, Indiana.

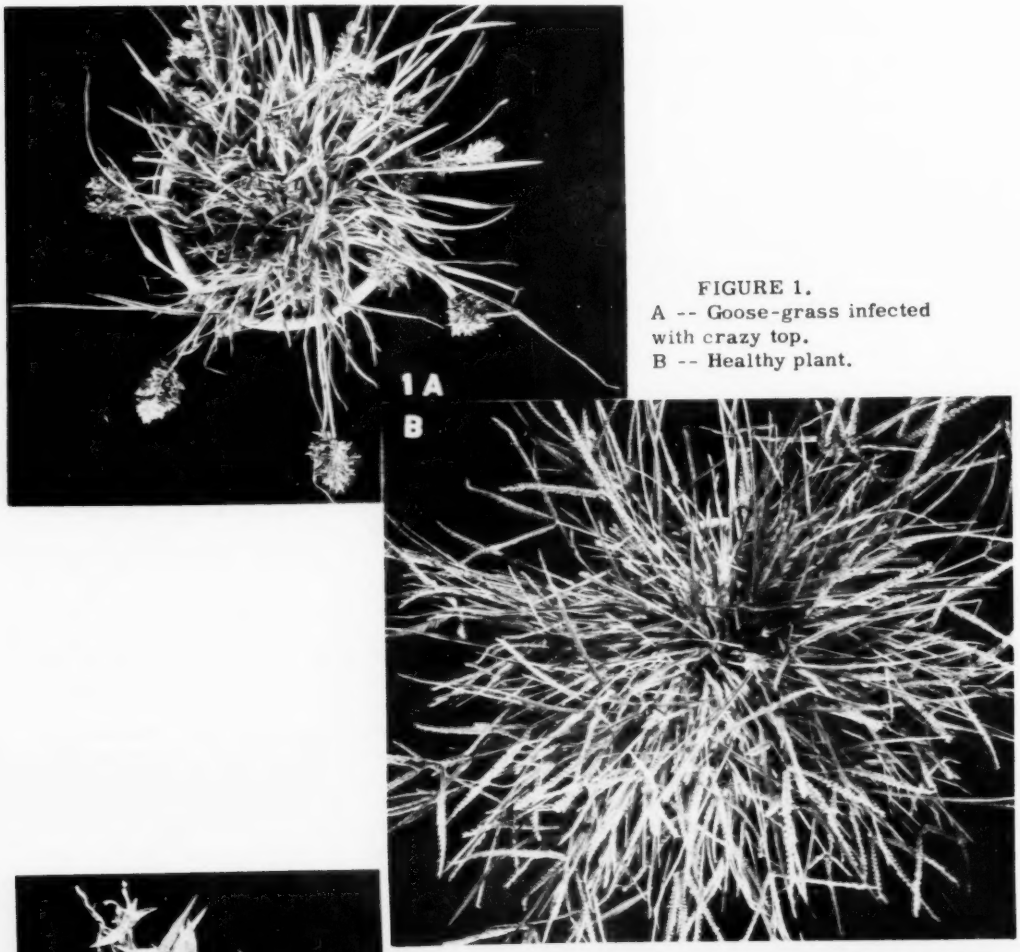

FIGURE 1.
A -- Goose-grass infected with crazy top.
B -- Healthy plant.

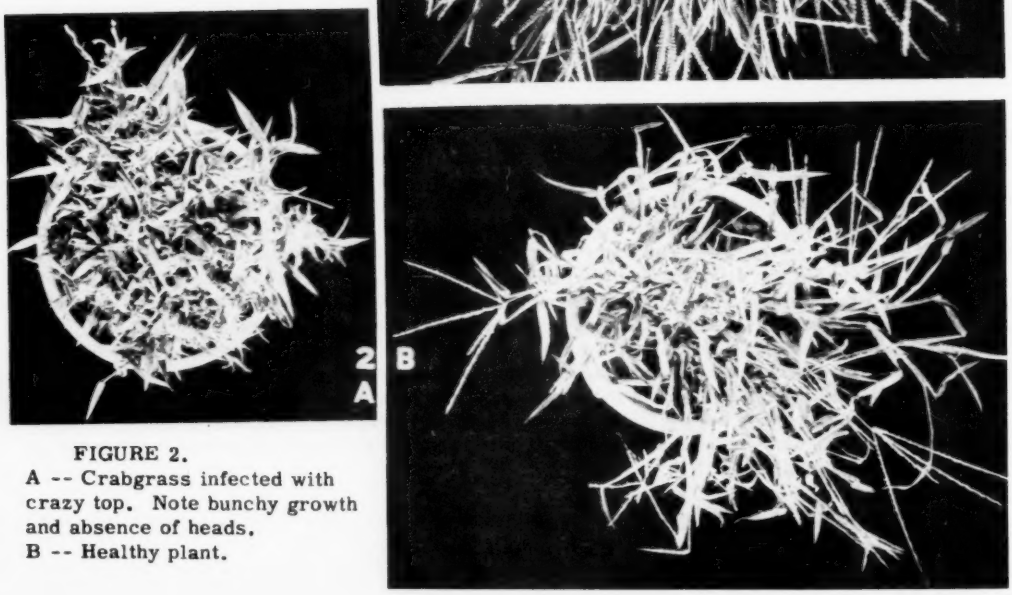

FIGURE 2.
A -- Crabgrass infected with crazy top. Note bunchy growth and absence of heads.
B -- Healthy plant.

FIGURE 3. Typical lemon-shaped sporangium found very sparingly on both crabgrass and corn leaves.

with crazy top were found in a corn breeding nursery near Lafayette, Indiana. One of these plants was severely infected and bore the typical narrow, strap-like and striated leaves (5). Neither staminate nor pistillate inflorescences developed on this plant. Microscopic examination of scrapings from the surfaces of leaves when the latter were still covered with dew (8:00 A.M.) showed a few typical sporangia (Fig. 3). Successive crops of sporangia were observed on subsequent mornings whenever leaves were wet with dew. The sporangia were strikingly similar to those found on crabgrass. They measured 20-84 x 62-109 μ (58 x 83 μ). Sporangiophores were hyphoid, simple or 2- to 3-branched and 10 to 15 μ in length. The sporangiophores resembled closely, in size, shape and color, those described by Thirumalacher et al. (4) for Sclerophthora macrospora on Eleusine coracana Gaertn.

Many corn plants affected by crazy top have been examined in the field and in moist chambers in the greenhouse for the presence of sporangia, but none have been found until the single instance reported here. Sporangia have been found occasionally on other hosts (2, 3, 4).

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COMPARATIVE EFFECTIVENESS OF HEXACHLOROBENZENE (HCB) AND MERCURY PREPARATIONS IN CONTROLLING SOIL-BORNE COMMON BUNT IN COMMERCIAL FIELD TRIALS[1]

C. S. Holton and L. H. Purdy[2]

The effectiveness of Anticarie (40% hexachlorobenzene) in controlling soil-borne common bunt (Tilletia caries (D.C.) Tul. and T. foetida (Wal.) Liro) when applied to wheat seed in experimental plots was reported recently[3] and has now been demonstrated on a commercial field scale with seed treated in a commercial plant[4]. In this demonstration two 40% HCB preparations (Anticarie and No-Bunt) and two standard mercury treatments (Ceresan M and Panogen) were used. All of these materials are highly effective against seed-borne inoculum but only the HCB preparations offer protection against soil-borne spores[3]. Thus, the mercury treatments served as checks to indicate the degree of soil infestation. All materials were applied to seed of Elmar wheat with a slurry treater at the rate of an ounce to the bushel, except for Ceresan M which was applied at 1-1/4 ounces to the bushel.

The treated seed was planted with commercial-type drills on two farms, a separate drill being used for each treatment. Seed treated with Ceresan M and Anticarie was planted on the Rees Bros. farm and that treated with Panogen and No-Bunt was planted on the Leisinger farm, both of which are located near Helix, Oregon. The seeding arrangement on both farms was in alternate drill strips of seed treated with mercury and HCB preparations. Each drill strip consisted of 20 drill rows. No untreated seed was sown. However, since both mercury and HCB are highly effective against seed-borne smut it may be assumed that any smut appearing in these crops originated from soil-borne spores.

Relative effectiveness of the pairs of materials was determined by general observation on smut prevalence in adjacent drill strips and by smut percentages based on counts of 100 to 200 heads taken at random in adjacent drill strips. Most of the sample counts were made in pairs directly opposite each other in the drill strips. A summary of the counts made is presented in Table 1. In this tabulation all percentages were rounded off to the nearest whole number.

It is clearly evident from the data in Table 1 that there was markedly less smut on both farms in the crop grown from HCB-treated seed than in that grown from mercury-treated seed. On the Rees Bros. farm the smut percentages in the sample counts in the Ceresan M treated strips ranged from 2 to 33, the average being 15.7. Comparable counts in the Anticarie-treated strips showed a range of 0 to 7 percent, with an average of 2.8 percent. These sample counts bore out the general observation throughout the field that wheat in drill strips grown from seed treated with Anticarie was consistently less smutty.

The level of infection on the Leisinger farm was generally low, ranging from 2 to 9 percent in the sample counts of the Panogen area, the average being 5 percent. In contrast, there was strikingly less smut in the No-Bunt drill strips, the sample counts showing 0 to 1 percent with an average of 0.3 percent. These sample counts bore out the general observation that there was noticeably less smut in the HCB drill strips throughout the field than in the Panogen drill strips.

From these observations it seems conclusive that hexachlorobenzene preparations of 40%

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[1] Cooperative investigations of the United States Department of Agriculture, Agricultural Research Service, Field Crops Research Branch, and the Agricultural Experiment Stations of Idaho, Oregon and Washington.

[2] Pathologists, U.S. Dept. of Agr., Field Crops Research Branch, ARS, Pullman, Wash. We are indebted to Mr. P. H. Kibbey, Manager, Farmers Union Warehouse Co., Helix, Oregon, for promoting this comparative commercial demonstration and to Mr. G. A. Mitchell, Agricultural Advisor, Farm Chemicals, Inc., Athena, Oregon, for calling our attention to the demonstration. Acknowledgement is also made to E. L. Kendrick of the Regional Smut Research Laboratory and Merrill D. Sather of the Pacific Northwest Crop Improvement Association for assistance in taking data. Thanks are also due C. E. Horner, Pathologist of the Oregon Experiment Station, who reported to us that his independent observations and sample counts on one of the farms confirm those reported here.

[3] Holton, C. S., and L. H. Purdy. 1954. Control of soil-borne common bunt of winter wheat in the Pacific Northwest by seed treatment. Plant Dis. Reptr. 38: 753-754.

[4] Farmers Mutual Warehouse Co., Helix, Oregon.

Table 1. Summary of head counts made in commercial fields to determine relative prevalence of smut in wheat grown from seed treated commercially with mercury and HCB preparations.

Farm, treatment, sample number, number of heads per sample, and percent of smut								
Sample number	Rees Bros. Farm				Leisinger Farm			
	Ceresan M		Anticarie		Panogen		No Bunt	
	No. Heads	% Smut	No. Heads	% Smut	No. Heads	% Smut	No. Heads	% Smut
1	200	11	200	4	200	5	200	0
2	200	18	200	1	200	3	200	0
3	200	18	200	1	200	4	200	0
4	200	15	200	3	200	7	200	0
5	100	33	200	2	200	4	200	0
6	200	8	200	1	200	5	200	1
7	100	12	100	0	200	9	200	1
8	200	12	200	3	200	5	200	0
9	200	7	200	2	200	6	200	1
10	200	24	200	3	200	4	200	0
11	100	12	100	7	200	5	200	0
12	100	15	100	2	200	8	200	1
13	100	32	100	5	200	4	200	0
14	100	32	100	4	150	4	200	1
15	100	16	100	0	125	5	200	0
16	200	17	200	3	200	7	200	1
17	200	2	200	3	150	4	200	0
18	200	4	200	2	200	2	200	0
19	200	4	200	0	200	4	200	0
20	200	24	200	2	200	5	200	0
Averages:		15.7		2.8		5		0.3

active ingredient, used as a seed treatment at the rate of at least one ounce to the bushel, may be expected to reduce markedly the amount of common smut in wheat originating from soil-borne spores. This is in line with experimental results obtained in the past 3 years and suggests the possibility of more effective control of smut by seed treatment with these materials.

COOPERATIVE INVESTIGATIONS OF THE UNITED STATES DEPARTMENT OF AGRICULTURE, AGRICULTURAL RESEARCH SERVICE, FIELD CROPS RESEARCH BRANCH, AND THE AGRICULTURAL EXPERIMENT STATIONS OF IDAHO, OREGON AND WASHINGTON

REGIONAL SEED TREATMENT TESTS FOR THE CONTROL OF SEED-BORNE AND SOIL-BORNE COMMON SMUT OF WINTER WHEAT IN THE PACIFIC NORTHWEST[1]

Laurence H. Purdy[2]

Summary

Twenty-eight chemical preparations were tested as seed treatments for wheat smut control in 10 regional nurseries in 5 Pacific Northwest States. These materials included 19 formulations of mercury, 6 HCB preparations, and 3 other non-mercurials.

The performance of all materials was consistent at all locations.

Good control of smut caused from infection by seed-borne spores was obtained with 12 mercury preparations and 4 brands of HCB. The 9 mercuries which gave only fair or poor control in this test were all phenylmercury derivatives.

Good protection against infection of wheat by soil-borne smut spores was provided by all 40% formulations of HCB at rates ranging from 1/2 to 2 ounces per bushel. Terraclor, a PCNB preparation, also gave good protection at rates of 1 and 2 ounces per bushel.

All of the HCB preparations tested and Terraclor were effective simultaneously against infection by seed-borne and soil-borne spores.

Introduction

Common bunt (Tilletia caries (D.C.) Tul. and T. foetida (Wal.) Liro) of winter wheat in the Pacific Northwest may be controlled by seed treatment with appropriate fungicides. Such fungicides may or may not perform equally well under a wide range of geographic and environmental conditions. Regional tests were initiated therefore to determine whether general recommendations on seed treatments can be made on a regional basis. These tests were designed to evaluate the fungicides for their effectiveness in controlling both seed-borne and soil-borne smut. Only those materials which are of immediate commercial interest were included.

Materials and Methods

Twenty-eight different chemical formulations were tested at 10 locations[3] in Washington, Oregon, Idaho, Utah, and Montana. These are listed below, with their respective active ingredients and manufacturers.

Agrox -- 6.7% phenylmercuriurea. Chipman Chemical Company, Bound Brook, New Jersey.

Anticarie -- 40% hexachlorobenzene. H. P. Rossiger Company, Inc., New York.

Captan-HCB 50-20 -- a mixture of 50% N-(trichloromethylthio)-4-cyclohexene-1, 2-dicarboximide and 20% hexachlorobenzene. California Spray-Chemical Corporation, Richmond, California.

Ceresan M -- 7.7% N-(ethylmercuri)-p-toluene-sulfonanilide. E. I. du Pont de Nemours & Co., Wilmington, Delaware.

Ceresan M-2X -- 15.4% N-(ethylmercuri)-p-toluenesulfonanilide. E. I. du Pont de Nemours & Co., Wilmington, Delaware.

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[1] Cooperative investigations of the U. S. Department of Agriculture, Agricultural Research Service, Field Crops Research Branch, and the Agricultural Experiment Stations of Idaho, Montana, Oregon, Utah, and Washington. Scientific Paper No. 1450, Washington Agricultural Experiment Stations, Pullman.

[2] Pathologist, Field Crops Research Branch, Agricultural Research Service, U. S. Department of Agriculture, Pullman, Washington.

[3] Grateful acknowledgement, by location, is extended to the cooperators who assisted in these tests: Bozeman, Montana (Prof. H. E. Morris and Dr. E. R. Hehn); Elgin, Oregon (W. H. Miller); Genesee, Idaho (C. Herman); Kalispell, Montana (W. W. Mauritson and V. R. Stewart); Lind, Washington (W. L. Nelson); Logan, Utah (Prof. D. C. Tingey); Moro, Oregon (W. E. Hall); Moscow, Idaho (Drs. C. W. Hungerford, A. M. Finley, and K. H. Klages); Pendleton, Oregon (C. R. Rohde and M. M. Oveson); Worley, Idaho (E. W. Bitters).

Copper carbonate -- 52% copper. Mountain Copper Co. Limited, San Francisco, California.

Dow HCB -- 40% hexachlorobenzene. Dow Chemical Co., Midland, Michigan.

HCB-Captan-Lindane -- a mixture of 8% hexachlorobenzene; 20% captan; 20% gamma isomer of 1, 2, 3, 4, 5, 6-hexachlorocylohexane. California Spray Chemical Corp., Richmond, California.

Liquid Mercury 244 -- a mixture of 2.27% phenylmercury acetate and 1.57% ethylmercury acetate. E. I. du Pont de Nemours & Co., Wilmington, Delaware.

Liquid Mercury 364 -- a mixture of 5.0% phenylmercury acetate and 0.95% ethylmercury acetate. E. I. du Pont de Nemours & Co., Wilmington, Delaware.

Mema -- 11.4% 2-methoxymethylmercury acetate. Chipman Chemical Co., Bound Brook, New Jersey.

Mema + Aldrin --? % Mema plus ? % Aldrin. Chipman Chemical Co., Bound Brook, New Jersey.

Merculine 100 -- 10% phenylmercury salicylate. H. L. Woudhuysen, New York.

Mergamma -- a mixture of 1.93% phenylmercuriurea and 40% gamma 1, 2, 3, 4, 5, 6-hexachlorocyclohexane. Chipman Chemical Co., Bound Brook, New Jersey.

Mer-kote -- 5.37% phenylmercury acetate. Stauffer Chemical Co., North Portland, Oregon.

Mer-lin 1-37 -- a mixture of 1.68% phenylmercury acetate and 37% gamma 1, 2, 3, 4, 5, 6-hexachlorocyclohexane. Stauffer Chemical Co., North Portland, Oregon.

Mer-sol -- 7.0% phenylmercury acetate. Stauffer Chemical Co., North Portland, Oregon.

No Bunt -- 40% hexachlorobenzene. Chipman Chemical Co., Bound Brook, New Jersey.

Panogen 15 -- 2.2% cyano(methylmercuri)guanidine. Panogen, Inc., Ringwood, Illinois.

Panogen 42 -- 6.3% cyano(methylmercuri)guanidine. Panogen, Inc., Ringwood, Illinois.

PMU + Aldrin -- a mixture of ? % phenylmercuriurea and aldrin. Chipman Chemical Co., Bound Brook, New Jersey.

Puratized C13-1212 -- ? % N-phenylmercuriformamide: anilino-cadmium lactate. Gallowhur Chemical Corp., New York.

Sanocide -- 40% hexachlorobenzene. California Spray-Chemical Corp., Richmond, California.

Setrete -- 7.0% phenylmercury acetate. W. A. Cleary Corp., New Jersey.

Tag #331 -- 10% phenylmercury acetate. California Spray-Chemical Corp., Richmond, California.

Terraclor -- 75% pentachloronitrobenzene. Mathieson Chemical Corp., Baltimore, Maryland.

Vancide 51 -- 30% sodium dimethyldithiocarbamate; sodium derivative of 2-mercaptobenzothiazole. R. T. Vanderbilt Co., New York.

Velsicol -- 10.34% 1, 4, 5, 6, 7, 7-hexachloro-N-(ethylmercuri)bicyclo [2.2.1] hept-5-ene-2, 3-dicarboximide. Velsicol Corp., Chicago, Illinois.

Two varieties of winter wheat were used. Rio, a hard red wheat, was planted at Kalispell and Bozeman, Montana; Lind, Washington; and Genesee, Idaho; and Orin, a soft white wheat, was planted at the other locations.

The seed was treated in units of 250 mls. The wettable powders and liquids were applied in slurry and dilute or concentrated forms, respectively. Rates of application ranged from 0.2 to 4 ounces per bushel and were based on fractions or multiples of the 1/2 ounce rate. To apply wettable powders at 1/2 ounce per bushel 120 mgs. were placed in a vial to which two mls. of water were added. Two to four drops of Methocel (5% methylcellulose) were added to act as a spreader and sticker. This was made into a slurry and poured into a liter Erlenmeyer flask containing the unit of seed to be treated. The fungicide was distributed over the seed by shaking the flask until all free moisture had disappeared from the inner wall. Higher rates of application were made by increasing proportionately the volume of slurry used. The treated seed was stored in paper bags for 2 to 3 days and then transferred to seed envelopes where it was held for a similar period before planting.

Liquid fungicides to be applied at 1/2 ounce per bushel were diluted 1:16 and 2 mls. of this

Table 1. Summary of results obtained from 9 regional tests of seed treatment fungicides for the control of seed-borne common bunt in winter wheat planted in the Pacific Northwest States, 1955.

Treatment	Form	Rate[a]	Arc sine mean	Percent bunt[b]	Statistical significance
Check - untreated			66.898	84.5	
Mema + Aldrin	L[c]	2	50.878	60.2	
Panogen PA-2N	L	4	36.368	35.2	
Copper carbonate	D[d]	2	35.649	34.0	
Copper carbonate	S[e]	2	30.089	25.1	
Vancide 51	L	4	21.873	13.9	
Sanocide	S	1/2	16.678	8.2	
Mer-lin 1-37	L	2	15.866	7.5	
Mergamma	S	1 3/4	15.530	7.2	
Dow HCB	S	1/2	15.200	6.9	
Captan-HCB 50-20	S	1	14.154	5.9	
Agrox	S	1/2	12.304	4.5	
No Bunt	S	1/2	12.185	4.4	
Mer-kote	S	1/2	11.720	4.1	
Merculine 100	L	1/2	10.993	3.6	
PMU + Aldrin	S	2 1/2	10.714	3.5	
Mergamma	S	2 1/2	10.439	3.3	
HCB-Captan-Lindane	S	3	10.376	3.2	
Setrete	L	1/2	10.334	3.2	
Mer-sol	L	1/2	10.130	3.1	
Anticarie	S	1/2	9.866	2.9	
Terraclor	S	1	8.946	2.4	
Dow HCB	S	1	5.451	0.90	
Tag #331	L	1/2	5.327	0.86	
Sanocide	S	1	5.315	0.86	
No Bunt	S	1	4.481	0.61	
Anticarie	S	1	3.605	0.39	
Velsicol (50-CS-46)	S	1/2	3.423	0.36	
Liquid Mercury 244	L	3/4	3.404	0.35	
Liquid Mercury 364	L	1/2	3.173	0.31	
Mema	L	1/2	2.590	0.20	
Mer-lin 1-37 dry	S	2 2/3	2.280	0.16	
Ceresan M	S	1/2	2.034	0.12	
Puratized C13-1212	S	1/2	1.613	0.08	
Ceresan M-2X	S	1/4	1.484	0.07	
Velsicol (50-CS-46)	L	1/2	1.465	0.06	
Panogen 15	L	3/4	1.417	0.06	
Panogen 42	L	0.2	0.773	0.02	

[a] Rate in ounces per bushel.

[b] Reconstructed from arc sine mean.

[c] Liquid.

[d] Dust.

[e] Slurry.

dilution were used to treat 250 mls. of seed. Higher rates of application were made by altering the dilution ratio accordingly. Panogen PA-2N and Vancide 51 were applied undiluted at 4 fluid ounces per bushel. This was done by applying 0.85 ml. of the fungicide to 250 mls. of seed.

The treatments were planted in 3 replications of randomized 10-foot single rows. Smut percentages were determined on the basis of number of smutted heads in a total of 200. Calculations of percentages and statistical analyses of the data were performed by the Tabulated Records Department of Washington State College and J. G. Darroch, Washington Experiment Stations Statistican.

Table 2. Average percent bunt in 9 regional tests of seed treatment fungicides for the control of soil-borne common bunt by seed treatment in winter wheat planted in bunt-inoculated soil in the 5 Pacific Northwest States, 1955.

Treatment	Form	Rate[a]	Arc sine mean	Average percent bunt[b]	Statistical significance
Check - untreated			48.038	55.3	
Panogen 15	L[c]	3/4	35.918	34.4	
Panogen 15	L	1.5	30.856	26.3	
Captan-HCB 50-20	S[d]	1/2	27.219	20.9	
Terraclor	S	1/2	19.486	11.1	
Dow HCB	S	1/2	18.722	10.3	
Captan-HCB 50-20	S	1	18.036	9.6	
No Bunt	S	1/2	16.780	8.3	
Sanocide	S	1/2	16.146	7.7	
Terraclor	S	1	14.740	6.5	
Anticarie	S	1/2	13.641	5.6	
Captan-HCB 50-20	S	2	13.589	5.5	
No Bunt	S	1	12.416	4.6	
Dow HCB	S	1	12.360	4.6	
Panogen 15	L	3	11.192	3.8*	
Anticarie	S	1	10.398	3.3	
Dow HCB	S	2	9.885	2.9	
Terraclor	S	2	9.732	2.9	
Sanocide	S	1	8.966	2.4	
Sanocide	S	2	8.414	2.1	
Anticarie	S	2	8.192	2.0	
No Bunt	S	2	8.070	2.0	

See footnotes in Table 3.

Table 3. Average percent bunt in 9 regional tests for the control of seed and soil-borne bunt by seed treatment in inoculated winter wheat planted in inoculated soil in the 5 Pacific Northwest States, 1955.

Treatment	Form	Rate[a]	Arc sine mean	Average percent bunt[b]	Statistical significance
Check - untreated			63.507	80.1	
Panogen 15	L[c]	3/4	35.263	33.3	
Panogen 15	L	1.5	31.267	27.0	
Captan-HCB	Sd	1/2	28.979	23.5	
Terraclor	S	1/2	24.866	19.0	
Sanocide	S	1/2	20.879	12.7	
Dow HCB	S	1/2	19.718	11.4*	
Panogen 15	L	3	19.609	11.3*	
Captan-HCB	S	1	19.588	11.2	
No Bunt	S	1/2	18.219	9.8	
Terraclor	S	1	16.276	7.9	
Anticarie	S	1/2	15.701	7.3	
Sanocide	S	1	14.587	6.3	
Dow HCB	S	1	12.612	4.8	
Anticarie	S	1	12.428	4.6	
No Bunt	S	1	12.083	4.4	
Captan-HCB	S	2	11.383	3.9	
Dow HCB	S	2	10.332	3.2	
No Bunt	S	2	10.331	3.2	
Anticarie	S	2	9.845	2.9	
Terraclor	S	2	9.425	2.7	
Sanocide	S	2	9.378	2.7	

[a] In ounces per bushel.

[b] Reconstructed from Arc sine mean.

[c] Liquid.

[d] Slurry.

* Panogen at 3 ounces per bushel reduced the stand severely so that these particular readings may not be reliable.

Statistical significance was determined by the Duncan[4] method of least significant ranges. This is presented in Tables 1, 2, and 3 under the column titled "Statistical Significance." Treatments that are enclosed by an individual line are not significantly different. Treatments not enclosed by an individual line are significantly different from those treatments within the limits of that line. For example, in Table 1 treatments Sanocide to Anticarie, inclusive, are not significantly different among themselves but are significantly different from all other treatments.

Results

The performance of all materials was essentially the same in all of the 10 nurseries. Analysis of the data was therfore based on averages and only 9 of the nurseries[5] were included. The results of tests on control of seed-borne smut are presented in Table 1.

The high incidence of 84.5 percent smut in the untreated check was reduced to less than 10 percent by all except 5 of the treatments. Sixteen of the treatments reduced the incidence to less than 1 percent, and 16 others were in the range between 2.4 and 8.2 percent. Within these 2 groups there were no significant differences between treatments, except that Terraclor at the 1 ounce rate was significantly better than Sanocide at the 1/2 ounce rate.

All treatments in the range of less than 1 percent were significantly better than those in the 2.4 to 8.2 percent range and those in this latter group were significantly better than the 5 treatments that allowed more than 10 percent smut to develop. Thus, for smut control values, the treatments in Table 1 may be classed as poor, fair, and good, with 5 in the poor class and 16 each in the other two classes.

The group of treatments which gave good control includes 4 different brands of HCB 40% formulations and 12 mercury preparations. It should be noted that the HCB preparations which gave good control at the 1-ounce rate (Anticarie, No Bunt, Sanocide, and Dow HCB) gave only fair control at the generally recommended rate of 1/2 ounce, thus suggesting the need for a revision upward in the rate recommendations. All of the mercury preparations which gave good control were used at the standard recommended rates of application.

Aside from Terraclor and the HCB preparations already mentioned, the group which gave only fair control included 9 mercury preparations, all of which are phenylmercury derivatives. This would indicate that mercuries of this type are basically less effective than the other types included in this study. That dry and liquid forms of the same mercury compound may not necessarily be equally effective against wheat smut is shown in the performance of Mer-lin 1-37, which was only fairly effective in liquid form but gave good control in dry form.

The seed treatment tests with uninoculated seed for the control of soil-borne common smut included 7 materials at 3 rates of application each, for a total of 21 treatments. Six of the materials were HCB 40% preparations, one was a PCNB product, and one was a mercury compound. The results were averaged from the nine locations and are summarized in Table 2.

Sixteen treatments reduced the incidence of bunt from 55.3 percent in the untreated check to less than 10 percent, while 5 treatments allowed more than 10 percent infection. In the group of treatments that reduced the incidence to less than 10 percent only Captan-HCB 50-20 at 1 ounce per bushel and No Bunt at 1/2 ounce per bushel provided inadequate control. The other 14 treatments in this group reduced the incidence of smut to less than 8 percent, with no significant differences between treatments (Table 2). Thus, all of these 14 treatments effected a marked reduction in the incidence of smut infection by soil-borne spores when applied to the seed at the rates indicated.

Only two of the 40% HCB formulations (Anticarie, Sanocide) gave good control at all three rates of application. The other two (Dow HCB and No Bunt) and Terraclor gave adequate protection at the 1- and 2-ounce rates while Captan-HCB 50-20 was effective only at the 2-ounce rate. Panogen 15 at 3 ounces per bushel fell into this group only because the severe stand reduction at this rate of application distorted the smut percentage. At the lower rates with Panogen neither the stand nor the incidence of smut was appreciably reduced. Mercury treatments in general are not effective as seed treatments against infection by soil-borne smut spores[6].

With regard to rate of application, coverage and adhesiveness are important factors to con-

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[4] Duncan, D. B. 1953. Multiple range and multiple F tests. Virginia Agric. Exp. Sta. Tech. Report 6a.

[5] Results from Elgin, Oregon, were not included because of the complicating factor of a natural infestation of dwarf bunt.

[6] Holton, C. S., and L. H. Purdy, Jr. 1954. Control of soil-borne common bunt of winter wheat in the Pacific Northwest by seed treatment. Plant Dis. Reptr. 38: 753-754.

sider. Thorough coverage of the seed is difficult to attain at 1/2 ounce per bushel while at 2 ounces all of the material does not adhere to the seed. The 1-ounce rate provides thorough coverage, good control, and adheres well. This then would be the logical rate of application to use.

Tests were also conducted to determine if seed-borne and soil-borne common bunt could be controlled simultaneously by seed treatment. The seed was inoculated and planted in soil that had been inoculated with smut spores. Results of this test in 9 nurseries were averaged and are presented in Table 3. The higher disease incidence in the untreated check in this test compared to that in Table 2 may be attributed to seed-borne spores.

Thirteen treatments reduced the disease incidence from 80.1 percent in the untreated check to less than 10 percent, the range for this group being 2.7 to 9.8 percent (Table 3). The differences within the group were not significant but the group as a whole was significantly better than the other 8 treatments. The relative position of the treatments with regard to control is similar to their positions in Table 2. Good control was obtained with the 40% HCB formulations at 1 and 2 ounces per bushel, and two of them (Anticarie and No Bunt) were just as effective at 1/2 ounce.

It is noteworthy that Panogen 15 reduced the disease incidence to almost the same level as in the tests with soil-borne spores only (Table 2). This shows that the control of seed-borne smut by Panogen 15 was good while there was no protection against soil-borne smut.

COOPERATIVE INVESTIGATIONS OF THE U. S. DEPARTMENT OF AGRICULTURE, AGRICULTURAL RESEARCH SERVICE, FIELD CROPS RESEARCH BRANCH, AND THE AGRICULTURAL EXPERIMENT STATIONS OF IDAHO, MONTANA, OREGON, UTAH, AND WASHINGTON.

COMPARATIVE PHYTOTOXICITY OF SEED TREATMENT FUNGICIDES USED FOR WHEAT SMUT CONTROL IN THE PACIFIC NORTHWEST[1]

L. H. Purdy[2]

Introduction

Phytotoxicity is one of the hazards accompanying the chemical treatment of wheat seed for smut (Tilletia spp.) control in the Pacific Northwest. Most of the materials now used for wheat seed treatment in this region are mercury compounds which are relatively safe when used at recommended rates. At higher rates, seed injury may result unless there is sufficient margin of safety to allow for overdosages applied accidentally or otherwise. Little is known, however, about relative margins of safety in these materials, especially as related to such factors as wheat variety and environment. Comparative studies were made, therefore, on the phytotoxic properties of four standard preparations used for wheat seed treatment to control smut in the Pacific Northwest. Preliminary tests with these materials indicated that differential phytotoxicity was exhibited by the mercury compounds[3]. The results of later more extensive tests reported herein do not substantiate those reported previously.

Materials and Methods

Three varieties of winter wheat (Elmar, Brevor, Rio) and four varieties of spring wheat (Idaed, Baart, Federation, Marfed) were used. The four of the standard fungicides chosen for study included Anticarie (40% hexachlorobenzene), Agrox (6.7% phenylmercuriurea), Ceresan M (7.7% N-(ethylmercuri) p-toluenesulfonanilide), and Panogen 15 (2.2% cyano(methylmercuri)-guanidine). They were applied to the seed of all varieties at 8 rates, including the rate recommended for commercial application. Anticarie, Agrox, and Ceresan M are applied commercially at 1/2 ounce per bushel and Panogen 15 at 3/4 ounce per bushel. The other rates of application for all four materials were 1, 2, 3, 4, 5, 8, and 10 ounces per bushel. The three wettable dust materials (Anticarie, Agrox, and Ceresan M) were applied in slurry form, while Panogen 15 was applied in a dilute form. The slurry preparations were made by agitating 120 mg. of the fungicide in a vial with 2 ml. of water containing 2-4 drops of 5% methylcellulose. This slurry-type suspension was poured onto 250 ml. of wheat seed in a one-liter Erlenmeyer flask. Panogen 15 was diluted 1 to 9 with water, and 1.5 ml. of this dilution was used to apply 3/4 fluid ounce per bushel to 250 ml. of seed in an Erlenmeyer flask. The flasks containing the seed and fungicides were shaken vigorously until all visible evidence of moisture on the inner wall of the flask was removed.

The higher rates of application were made by increasing the amount of dust fungicide in increments of 240 mg., an amount equal to 1 ounce per bushel on 250 ml. of seed. The different rates of Panogen 15 were obtained by proportionate increases in amounts of the original dilution per 250 ml. of seed. At rates above 5 ounces per bushel, a 1 to 4.5 dilution was used to avoid excessive wetting of the seed.

One hundred seeds of each variety and each rate of fungicide application were planted in the field in randomized 5-foot rows with three replications per treatment. In the greenhouse tests, 50 seeds per row were planted. All seed was held in closed paper bags in the laboratory for 10 days or longer prior to planting. All varieties and treatments were grown in the greenhouse and from spring seeding in the field. Only the winter wheats were grown from fall seeding in the field. Stand counts were made 4 to 5 weeks after planting, and the percentages of stands were based on total number of seeds planted per row. The results are presented in Tables 1 and 2 for winter and spring wheats, respectively.

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[1] Cooperative investigations of the U. S. Department of Agriculture, Agricultural Research Service, Field Crops Research Branch, and the Agricultural Experiment Stations of Idaho, Oregon, and Washington. Scientific Paper 1438, Washington Agricultural Experiment Stations, Pullman.

[2] Pathologist, U. S. Department of Agriculture, Field Headquarters at Agr. Exp. Station, Pullman, Washington.

[3] Purdy, L. H. Jr., and C. S. Holton. 1954. Differences in phytotoxic properties exhibited on spring wheat by fungicides used for smut control. (Abstr.) Phytopath. 44: 503.

Table 1. Percent stand in 3 varieties of winter wheat treated with different rates of 4 fungicides and planted in the field and greenhouse.

		Variety, location, time of planting, and percent stand.								
		ELMAR			BREVOR			RIO		
		Field		Green House	Field		Green House	Field		Green House
Treatment	Rate*	Spring	Fall	---	Spring	Fall	---	Spring	Fall	---
Check	---	52	80	94	62	85	96	42	78	92
Anticarie	1/2	56	84	94	64	88	96	44	80	90
	1	67	80	96	54	59	96	33	76	84
	2	55	80	94	54	91	96	38	80	86
	3	50	81	92	78	91	92	39	87	92
	5	54	83	94	63	89	98	42	54	92
	10	56	80	92	66	87	96	29	68	88
Agrox	1/2	39	70	96	68	87	98	45	27	98
	1	54	73	92	51	73	96	52	10	96
	2	53	33	82	54	21	88	40	0	86
	3	29	22	76	43	0	68	15	1	56
	5	22	0	44	10	1	38	7	2	44
	10	2	1	4	1	0	2	0	0	6
Ceresan M	1/2	57	89	98	60	89	96	50	79	98
	1	59	85	90	50	86	92	48	68	96
	2	56	66	84	48	46	86	60	19	94
	3	37	49	76	51	31	70	56	9	70
	5	23	8	36	17	4	28	24	5	38
	10	0	0	0	0	0	0	4	0	2
Panogen 15	3/4	43	79	92	53	83	92	50	81	96
	1	55	75	92	55	50	90	55	60	94
	2	42	29	70	21	29	58	34	23	70
	3	35	29	64	31	5	76	25	9	60
	5	7	9	30	9	26	14	8	4	30
	10	4	8	14	0	0	2	9	0	18

* Ounces per bushel.

Results

Above 1 ounce per bushel the three mercurials tested were generally phytotoxic, as measured by stand reduction, on all three winter wheat varieties and on the spring wheat variety Federation (Tables 1 and 2). The degree of phytotoxicity increased proportionately with increasing rates of application so that the most severe stand reduction occurred at 10 ounces per bushel. In contrast to the general phytotoxicity pattern obtained with the mercurials, Anticarie, practically speaking, was non-phytotoxic at all rates of application. None of the fungicides tested increased the stand appreciably over the untreated check.

From the results obtained with mercurials, generalizations with respect to differential phytotoxicity are difficult if not impossible to make. At 3 ounces per bushel Ceresan M was less phytotoxic on the three winter wheat varieties than were the other two mercurials (Table 1). At 2 ounces per bushel Agrox and Ceresan M were slightly less phytotoxic than Panogen 15, while at 8 and 10 ounces per bushel Panogen 15 was less phytotoxic than the other 2 materials. At 1 ounce or less per bushel, all three mercurials were similarly non-phytotoxic.

Although exceptions may be noted, Panogen exhibited greater phytotoxicity than either Ceresan M or Agrox at rates of 2, 3, and 5 ounces on all spring wheat varieties except Federation (Table 2). At 8 and 10 ounces per bushel Ceresan M exhibited a greater degree of phytotoxicity than either of the other two mercuries. It should be noted that at the recommended rates of application all three mercury treatments were beneficial to the stands on all spring wheat varieties except Federation.

Table 2. Percent stand in 4 spring wheat varieties treated with different rates of 4 fungicides and planted in the field and greenhouse.

Treatment	Rate*	Variety, location, and percent stand.							
		IDAED		BAART		FEDERATION		MARFED	
		Field	Green House	Field	Green House	Field	Green House	Field	Green House
Check	---	57	83	49	83	57	84	66	89
Anticarie	1/2	56	80	50	82	47	84	70	90
	1	56	81	54	80	47	86	70	90
	2	57	87	51	78	50	84	73	91
	3	50	77	51	77	42	89	66	92
	5	45	66	48	73	49	86	70	84
	10	43	64	41	73	51	88	65	81
Agrox	1/2	65	91	60	87	50	87	71	92
	1	59	89	55	90	40	74	69	95
	2	55	90	58	88	37	71	70	89
	3	61	93	56	83	28	63	57	81
	5	38	77	27	80	23	45	31	45
	10	6	33	4	17	4	6	2	3
Ceresan M	1/2	68	93	59	94	52	75	61	92
	1	57	93	74	88	42	79	64	94
	2	55	91	61	90	37	57	56	85
	3	47	73	30	56	19	34	44	66
	5	17	34	13	33	9	17	9	13
	10	2	0	2	0	0	0	0	0
Panogen 15	3/4	58	91	63	84	52	79	67	89
	1	59	91	67	86	50	78	63	88
	2	36	71	40	72	40	64	62	90
	3	44	76	27	51	31	65	43	75
	5	5	14	2	7	9	24	2	6
	10	3	16	1	6	11	19	7	16

* Ounce per bushel.

A possible influence of environmental factors on degree of phytotoxicity is indicated by the fact that higher percentages of germination were obtained in the greenhouse than in the field with both winter and spring wheats (Tables 1 and 2). Also in the field tests, better stands were produced in the fall than in the spring seedings. No explanation can be offered for these differences, but moisture and temperature relationships may be important in this respect. This is suggested by the results from the spring and fall seedings of the three winter wheat varieties (Table 1). These data, though erratic, indicate slightly greater toxicity in the fall seedings, suggesting that low soil temperature favors mercury phytotoxicity. There is obvious need for more extensive work along this line.

The data reported here show that Anticarie used as a seed treatment for wheat smut control is non-phytotoxic, even at heavy rates of application, while the mercury preparations exhibit varying degrees of phytotoxicity at rates above 1 ounce per bushel. Under some conditions the mercury treatments improved the stands of some varieties slightly. Certain varieties (Rio and Federation) were more sensitive to the mercury treatments than were others.

COOPERATIVE INVESTIGATIONS OF THE U.S. DEPARTMENT OF AGRICULTURE, AGRICULTURAL RESEARCH SERVICE, FIELD CROPS RESEARCH BRANCH, AND THE AGRICULTURAL EXPERIMENT STATIONS OF IDAHO, OREGON, AND WASHINGTON

THE EFFECT OF TEMPERATURE ON THE RESPONSE OF OATS TO RACE 216 OF CROWN RUST[1]

M. C. Futrell and G. W. Rivers[2]

Abstract

Fifty-one southern oat varieties or selections were tested in the seedling stage in the greenhouse for their response to Puccinia coronata Cda. var. avenae Fr. & Led., race 216, at 65° and 85° F. A number of varieties and strains responded differently to this organism at the two temperatures. For the most part, varieties of Victoria parentage were more resistant at the cooler temperature, 65°. The selection (Arlington-Delair) x Trispernia (C.I. 6908) gave a susceptible reaction at 85° and a highly resistant reaction at 65° during January. Susceptibility decreased in tests later in the season when light intensities and daylengths were greater. A number of the Victoria derivatives were tolerant or moderately resistant to race 216 at low temperatures during the winter test periods. This moderate type of resistance may partly account for Victoria derivatives not becoming infected with crown rust under cool season temperatures in Texas.

Crown rust (Puccinia coronata var. avenae) is one of the most damaging diseases of oats in the southern United States. A better understanding of the effect of environment on the expression of disease symptoms is desirable in order to understand the behavior of varieties to attacks by pathogenic organisms and in breeding for resistance. The acreage of oats used for winter pasture in the southern United States has greatly increased during recent years. With this larger acreage of host material, the crown rust problem becomes increasingly important. Not only is the disease destructive to the local crop in the South, but overwintering and increase on oats sown for pasture are major factors in determining the races of the pathogen and the numbers of urediospores that will spread northward and threaten the oat crop grown for grain. Virulent races, such as 216, make this problem more complicated.

With this in mind, an investigation of the effect of temperature on the expression of crown rust symptoms in seedling oat plants has been conducted. Fifty-one southern oat varieties or experimental strains were tested in the seedling stage in the greenhouse. Seedlings were used because this period of growth represents the stage in which overwintering infections are initiated in the southern United States.

As early as 1918, Parker (2) pointed out that crown rust was one of the most destructive diseases of the southern oat crop. Murphy (1) proved that the Green Russian, Hawkeye, Anthony, Sunrise, Green Mountain, and White Tartar varieties were susceptible to race 7 of crown rust at 85° F and resistant at 55°. All of these varieties except White Tartar had a mesothetic response at an intermediate temperature. Both Murphy (1) and Peturson (3) demonstrated that disease expression induced by other physiologic races of crown rust is not so readily influenced by temperature. Murphy (1) and later Simons (4) showed that the incubation period for the crown rust organism was from 4 to 5 days longer at low temperatures. Peturson (3) further demonstrated that certain varieties of oats, inoculated and kept at 57° F for 4 days and moved to 78° for the remainder of the incubation period, were highly susceptible to crown rust, while the same varieties, inoculated and kept at 77° for 4 days and then moved to 57° for the remainder of the period, were resistant to crown rust.

Materials and Methods

In 1953 seedling plants of 24 varieties or selections of oats were tested for response to race 216 of crown rust. Cultures for this study were supplied by M. D. Simons and H. C. Murphy, United States Department of Agriculture and the Iowa Agricultural Experiment Station. The

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[1] Joint contribution from the Field Crops Research Branch, Agricultural Research Service, U. S. Department of Agriculture, and the Texas Agricultural Experiment Station, College Station, Texas. Texas Agricultural Experiment Station contribution No. 2183.

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Table 1. Response of oat varieties and selections to Puccinia coronata var. avenae Race 216 in the greenhouse at 2 temperatures and 3 dates in 1953 or 1954, at College Station, Texas.

Variety or selection	C. I. or Sel. No.	Response by dates inoculated and temperatures					
		1-16		2-10		3-26	
		85°F.	65°F.	85°F.	65°F.	85°F.	65°F.
New Nortex	3422	S	S	CS	CS	CS	S
Tennex x Victoria-Hajira-Banner	119-50-8	S	S	S	S	S	CS
Alber	2766	R	R	MR	MR	MR	R
Ranger	3417	S	S	S	S	S	CS
Rustler x D67-Bond	88-46-22	S	CS	S	CS	CS	CS
Mustang	4660	S	S	S	S	CS	S
Lee-Victoria x Fulwin (3770-1)	6717	S	S	CS	CS	CS	CS
Lee-Victoria x Fulwin (3770-7)	6571	MS	S	S	CS	CS	S
Frazier	2381	CS	CS	CS	CS	CS	CS
Fulgrain	5356	CS	S	CS	S	S	S
Victorgrain (48-93)	5355	CS	S	CS	S	S	CS
Floriland	6588	R	HR	HR	R	R	R
Southland	5207	MS	S	CS	S	S	S
Camellia	4079	R	R	R	R	R	R
Victoria-Hajira-Banner x Fultex	62-40-20	MS	MS	CS	S	MS	MS
Victoria-Hajira-Banner x Fultex	6923	R	R	R	MR	MR	R
Fultex	3531	CS	CS	CS	S	MS	CS
Appler	1815	S	S	CS	S	S	S
Delair	4643	MS	R	S	MR	S	MR
C.I. 4025 x (C.I. 4383-C.I. 4199) x Landhafer	6666	MR	MR	R	MR	R	R
C.I. 4025 x (C.I. 4383-C.I. 4199) x Landhafer	6574	MR	R	MR	R	MS	R
(Red Rustproof-Victoria) x Nortex	5372	S	S	S	S	S	S
Nortex Trelle Dwarf	6729	S	S	S	S	S	S
Nortex (0112)	5872	S	S	S	S	S	S
Atlantic x (Clinton^2-Santa Fe)	6605	MS	MR	S	MR	MR	MR

Table 1. (continued)

Variety or selection	C. I. or Sel. No.	Response by dates inoculated and temperatures					
		1-16		2-10		3-26	
		85°F.	65°F.	85°F.	65°F.	85°F.	65°F.
C.I. 4658 x (Clinton^2-Santa Fe)	6583	MR	MR	MS	S	-	-
Arlington	4657	MS	MS	S	CS	MS	S
Atlantic	4599	S	S	CS	CS	S	S
Victoria-Hajira-Banner	419-2-41	MR	MR	MS	S	MS	MS
Alamo	5371	CS	MS	CS	S	S	S
Victoria-Hajira-Banner x Fulghum-Victoria (73-46-7)	6719	S	S	S	S	S	MS
Victoria-Hajira-Banner x Fulghum-Victoria (4129-3-37)	6644	S	MR	S	S	S	MS
Victoria-Hajira-Banner x Fulghum-Victoria	4129-4-4	S	MR	S	MS	S	MS
Sunland	6600	R	R	MR	R	MR	HR
Seminole	5924	R	R	MR	R	MR	R
Atlantic x (Clinton^2-Santa Fe)	6910	S	S	S	S	S	CS
Wintok x (Clinton^2-Santa Fe)	6740	R	MR	R	MR	MR	HR
(Arlington-Delair) x Trispernia	6908	S	R	MS	MR	MR	R
(Sac x Hajira-Joanette) x Fla. 167	6599	MS	MR	CS	S	S	MS
(Atlantic x Clinton^2-Santa Fe) x Hajira-Joanette	6922	R	R	MR	MR	R	R
Desoto	3923	S	S	S	CS	MS	MS
Letoria	3392	S	S	S	S	MS	S
Stanton 1	3855	S	MS	CS	CS	S	S
Tenn. 090 x Bond	6731	S	S	CS	S	MS	S
Tenn. 090 x Bond	6732	S	MS	S	S	S	MS
Fulwin Composite Cross	152-50-6	S	MS	S	CS	CS	S
Tennex x Victoria-Hajira-Banner	110-50-1	S	S	S	S	CS	CS
Fulwin Composite Cross	152-50-21	S	MS	S	S	MS	MS
Landhafer x (Tennex x Victoria-Hajira-Banner)	222-50-88	R	R	MR	R	MR	MR

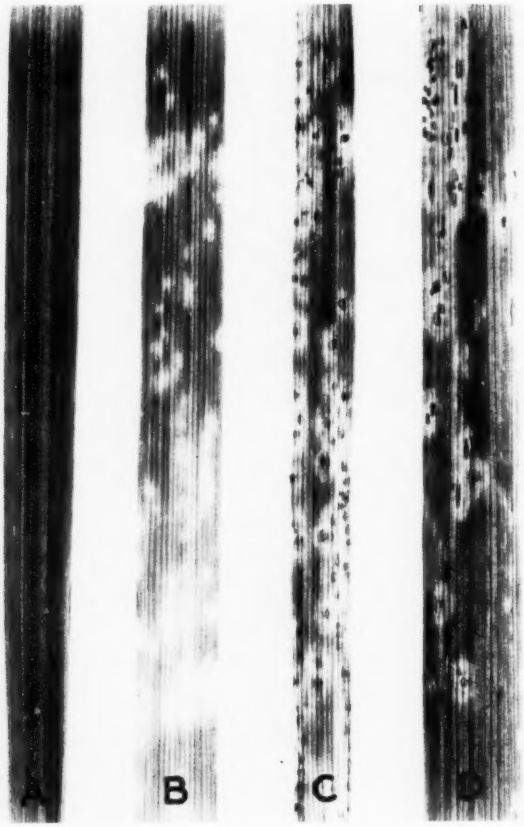

FIGURE 1. Reactions to crown rust race 216 on seedling plants in greenhouse at 85° F. (A) Sunland, (B) C.I. 6740, (C) Stanton-1, (D) Frazier.

preliminary study revealed that varieties responded differently at different periods of the year. The experiment was expanded in 1954 to include a total of 51 entries. Three to five replications were used in the tests. The completely susceptible variety, Frazier, was used as a check in all tests and Mustang was included in all as a type representing the Victoria derivatives susceptible to race 216 but resistant to the common races of crown rust. The inoculum of race 216 was further purified by increasing it only on Victoria derivatives that had previously been shown to be resistant to common races under field tests. Inoculations were made by rubbing leaves with a suspension of urediospores in tap water and incubating all plants at 85° F. One set of plants was then placed on a greenhouse bench where the air temperature ranged from 60° to 70° (averaging 65° F), and the other set was placed in a greenhouse having air temperatures ranging from 80° to 90° (averaging 85°). Notes were taken on uredial development when optimum symptoms were evident; about 10 days after inoculation at the high temperature and 14 days at the lower temperature.

Experimental Results

As observed by Murphy (1) and Simons (4), rust pustules developed much faster at the high temperatures. In a number of varieties or selections the response was the same at both temperatures. Typical resistant and susceptible reactions were observed among the strains tested. The responses of varieties and strains are given in Table 1 whereas in Figure 1 are shown four typical type reactions. Frazier was susceptible throughout all periods of the experiment. Stanton 1 ranged from moderately susceptible (Fig. 1) at the low temperature in first tests to com-

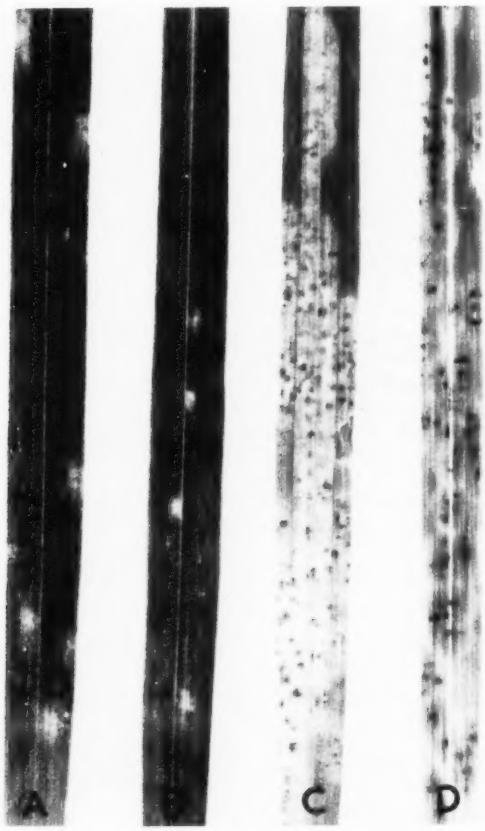

FIGURE 2. Reaction of C.I. 6908 to crown rust race 216 (A and B) at 65° F. (C and D) at 85° F.

pletely susceptible in later tests when temperatures were higher. A number of the entries gave resistant reactions but developed heavy chlorosis of the leaves in areas where the inoculum was applied. This is shown for C.I. 6740 in Figure 1. A number of varieties such as Sunland (Fig. 1), showed complete freedom from sporulation. Some seed lots of the Camellia variety responded differently to infection by this race, indicating that the variety was still heterozygous for reaction to this race or that such seed lots had become contaminated. Resistant lines were isolated and these pure seed lots of Camellia gave a resistant response under all conditions as shown in Table 1.

A sister selection of Alamo, 4129-4, of (Victoria x Hajira-Banner: C.I. 4019) x (Fulghum-Victoria: C.I. 3528) parentage was susceptible at 85° F but moderately resistant at 65° in the January 16 test. This difference was observed both in 1953 and 1954, but it was less pronounced later in the season when day lengths became longer. A selection, C.I. 6908, from an (Arlington-Delair) x Trispernia cross gave a susceptible reaction in the January tests at 85° but was highly resistant at 65°. This was one of the most pronounced differences due to temperature and is shown in Figure 2. As the daylength increased, this selection showed higher resistance at 85°, being moderately susceptible in February, and moderately resistant in the late March tests.

Discussion

Sister selections of Alamo, with the exception of C.I. 6719, gave a moderately resistant reaction at 65° and a susceptible reaction at 85° F in January tests; whereas in later tests during March when daylength was greater, there were no differences in the reactions at the two temperatures. This tendency was observed in a number of Victoria derivatives. In 1954 the

January and March periods had a large number of cloudy days; whereas period two was characterized by a large number of clear bright days with high light intensities. These data could be interpreted as a result of the interaction of the three factors, temperature, light intensity, and daylength, on the expression of crown rust symptoms in oat varieties of Victoria parentage. On the basis of this assumption, some specific combination of these three factors would result in oats of Victoria parentage exhibiting maximum symptom expression to race 216. Further studies under controlled conditions are needed to prove this hypothesis.

Epidemiology studies conducted in Texas have shown that fields seeded to oat varieties of Victoria parentage do not usually become heavily infected with crown rust early in the season. The tolerance or moderate type of resistance demonstrated by these varieties may reduce the overwintering of rust in areas where cooler temperatures prevail.

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FIELD CROPS RESEARCH BRANCH, AGRICULTURAL RESEARCH SERVICE, U. S. DEPARTMENT OF AGRICULTURE, AND DEPARTMENT OF AGRONOMY, DEPARTMENT OF PLANT PHYSIOLOGY AND PATHOLOGY, TEXAS AGRICULTURAL EXPERIMENT STATION, COLLEGE STATION, TEXAS

OCCURRENCE OF POLYMYXA GRAMINIS IN RED CLOVER ROOTS

J. W. Gerdemann

Polymyxa graminis Ledingham was first described as a parasite of wheat roots in southeastern Ontario (1). Ledingham also reported barley and rye to be susceptible and found resting spores similar to those produced by P. graminis in species of Agropyron, Scolochloa, Rumex, and Impatiens. Later Linford and McKinney (2) reported finding this fungus in wheat roots collected in Illinois and in pot culture materials derived from collections made in Virginia, Iowa, Kansas, and Oklahoma. They also reported finding the fungus in roots of spelt and emmer.

During the spring of 1955 red clover roots collected from a field on the Agronomy South Farm at Urbana were cleared and stained by boiling for about 5 minutes in a saturated aqueous solution of chloral hydrate containing approximately 0.01% acid fuchsin. After processing roots were examined microscopically in clear lactophenol. Clusters of resting spores (Fig. 1) were abundant in many of the roots. In one heavily infected rootlet over 600 spore clusters were counted in a section 3 mm. in length. These spore clusters appeared indistinguishable from those produced by P. graminis in roots of small grains and it is assumed that they belong to this species. The abundance of spore clusters suggests the possibility that this fungus may under certain conditions cause injury to red clover roots.

FIGURE 1. Clusters of resting spores of Polymyxa graminis in roots of red clover, x about 450

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CYLINDROCLADIUM SCOPARIUM MORGAN ON AZALEAS AND OTHER ORNAMENTALS

M. I. Timonin and R. L. Self[1]

Abstract

Cylindrocladium scoparium Morgan is reported as causing extensive losses of ornamental cuttings in propagation houses. The host range of the fungus was extended to eight new host species. The similarity of the disease symptoms, as well as the morphological characteristics of the causal fungus, C. scoparium, to those of Rhizoctonia, was noted.

In the spring of 1955, a destructive disease caused by Cylindrocladium scoparium Morgan appeared on azaleas in the shade houses and the greenhouse rooting benches of nurseries in Mobile County, Alabama. Losses of cuttings in the greenhouse varied from 10 to 100 percent. In the shade house, the damage consisted of retarded growth resulting from partial defoliation and of loss of the more succulent wood of plants grown under very humid conditions. The disease was later observed on azaleas in Baldwin County and on rooted cuttings of poinsettia in greenhouses at Montgomery, Alabama.

C. scoparium has worldwide distribution, and it was reported (2) on three widely separated families of plants. The present study has extended this range to eight new hosts: Indica azalea (Rhododendron indica), Kurume azalea (R. obtusa japonicum), Magnolia soulangeana, Hydrangea sp., Ilex rotundifolia, Pyracantha sp., bottle brush (Callistemon rigidus), and Poinsettia.

Materials and Methods

Several cultures of the fungus were isolated from the diseased stems and leaves of azalea cuttings and liners, using mercuric chloride (1/1000 dilution) as a surface sterilizing agent. The media used were potato dextrose agar and a modified yeast-extract-mannitol agar reported as medium 79 (4).

The modified yeast-extract-mannitol agar consisted of: KH_2PO_4, 0.4 gm.; $MgSO_4.7\ H_2O$, 0.1 gm.; NaCl, 0.1 gm.; $CaSo_4$, 0.05 gm.; cane sugar (granulated), 6 gm.; mannitol, 6 gm.; brown cane sugar, 2 gm.; yeast extract (Difco), 1.5 gm.; agar, 17 gm.; tap water, 1000 ml.; pH adjusted to 6.8-7.0 with NaOH solution.

Inoculated media were incubated at room temperature (26°-32°C). For inoculation purposes, the organism was grown in an aerated, liquid, modified yeast-extract-mannitol medium on which were produced abundant mycelia and sclerotia but no conidia. After 6 days' incubation, the mycelium was strained on cheese cloth and then macerated in a Waring blendor for 1 minute.

Inoculations were made by (a) spraying cuttings, (b) dipping cuttings, and (c) mixing the inoculum with terralite rooting medium. Inoculated plants were incubated in a moist chamber.

Description of the Organism

An orange-brown, white-margined mycelial growth developed on medium 79 in Petri dishes and test tubes after 3 days. The organism produced typical Cylindrocladium conidiophores and conidia. Numerous chlamydospores and sclerotial-like bodies of orange-brown color were also formed. Conidiophores, measuring 350 x 6-7 μ at the base, were dichotomously branched at the apex similar to Gliocladium. The phialides, 12.8 x 3.6 μ, bore cylindrical hyaline conidia 32.0-54.4 x 3.2-4.2 μ, seldom with one septum, and cemented together into a head. The typical Cylindrocladium monopodical hypha, originating at the base of a conidiophore and terminating in a mucoraceous columella, was also observed. The description of this organism agreed most closely with that of Cylindrocladium scoparium Morgan (1).

A white mycelial growth with numerous chlamydospores and sclerotia-like bodies was pro-

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FIGURE 1. Young liners of Hinodegari variety of Kurume azalea. Left, healthy check. Right, plant naturally infected with Cylindrocladium scoparium covered with polyethylene bag for 5 days. Note the defoliation and loss of succulent stem tips.

duced on potato-dextrose agar in Petri dishes after 6 days. After 7 to 10 days, the mycelial color began to change from white to cinnamon brown and a few conidiophores and conidia were observed. During the fourth week of incubation, the cultures produced abundant sporulation and numerous submerged sclerotia-like bodies. In test tubes the color of the mycelium remained white and no fruiting bodies were formed.

Symptoms and Signs of the Disease

On Azalea: The symptoms on azaleas were of two types, blight and wilt. These symptoms were observed on both naturally infected and inoculated plants.

Blight: (Figures 1 and 2)--Symptoms on infected azalea leaves both in the greenhouse and shade house consisted of a rapid spreading blight. Infected leaves turned brown to black de-

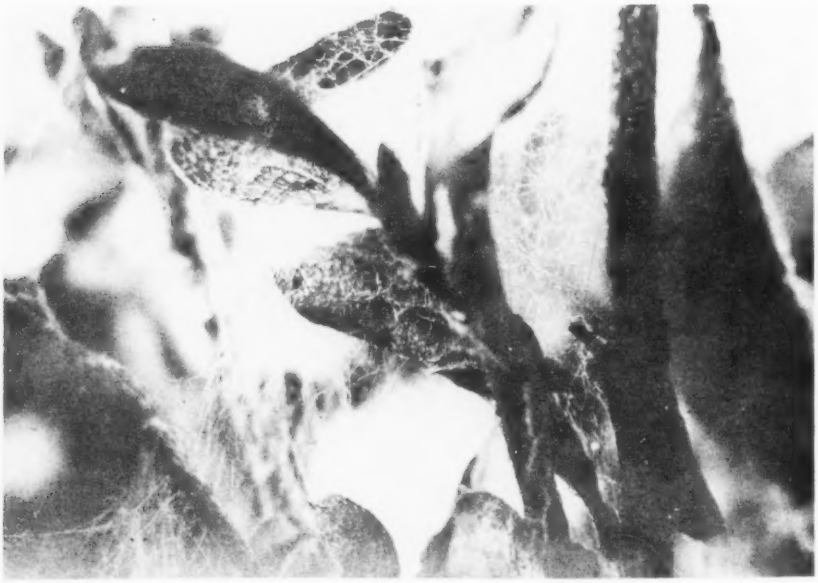

FIGURE 2. Closeup of Hinodegari azalea naturally infected with Cylindrocladium scoparium. Note the mass of cobweb-like mycelial strands.

pending on the variety, petiole bases softened, and the leaves usually dropped in 3 to 4 days. The bark of infected stems also turned brown in 3 to 4 days. In advanced stages, the leaves and stems were usually covered with a sparse to luxuriant mass of brownish mycelial strands. Powdery white masses of conidia were often observed on the stems of cuttings in the greenhouse. These symptoms and signs were reproduced on young rooted and unrooted azalea cuttings in the greenhouse by spray inoculations with liquid cultures.

Cutting wilt--This phase of the disease consisted of leaf wilt followed by leafdrop without the production of visible leaf spots or stem cankers. The bark and wood at the base of wilted cuttings were discolored and often watersoaked. In advanced stages, vascular discoloration sometimes extended to the cutting tip. This phase of the disease was observed in many nursery greenhouses. It also was reproduced on azalea cuttings inserted in the inoculated rooting medium. Wilting occurred 5 days later.

On Magnolia soulangeana: Symptoms produced on spray-inoculated plants consisted of a rapid spreading, black, soft rot of the leaves and succulent stem tips. Where the rooting medium was inoculated, a soft black decay developed quickly on the bark. On very succulent cuttings, this decay also involved the wood. On older wood, only a brownish vascular discoloration occurred, which sometimes extended to the upper tip of the cutting in 5 days. Later the disease was found on two separate plantings where almost complete defoliation had occurred.

On Pyracantha and Ilex rotundifolia: Symptoms on cuttings produced by inoculation were similar to those on azalea. In addition, the leaf spots on Pyracantha were zonated.

Discussion

Cylindrocladium damping-off and leaf blight is a serious disease of many ornamentals under conditions of high humidity. Symptoms may vary, depending upon the points of infection. Signs may be absent under conditions of low or varying humidity. On the other hand, under constant high humidity, the signs of the fungus were obvious, although they could be confused with those caused by Rhizoctonia. This confusion is possibly due to the presence of the diagnostic features of Rhizoctonia, i.e., brown mycelial strands and zonate lesions, on some of

the affected plants. Even after isolation of the organism in pure culture on potato-dextrose agar medium, it produces characteristics similar to those of Rhizoctonia as described above and by Cox and Comegys (3).

It is possible that, in many cases, Cylindrocladium has incorrectly been reported as Rhizoctonia. The authors suggest that isolations be made on both potato-dextrose and modified yeast-extract-mannitol agar media to assure proper identification.

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SWEETGUM BLIGHT IN LOUISIANA AS DETERMINED BY THE FOREST SURVEY

W. S. Stover[1] and E. Richard Toole[2]

Confirmation of earlier reports that blight or dieback of sweetgum (Liquidambar styraciflua L.) is widespread in Louisiana is provided by a recently completed Forest Survey of the State. The Forest Survey sampling indicates that, on the average, 8 percent of the good-tree volume of sweetgum is in trees with an important degree of blight. In 19 of the State's 64 parishes, the proportion of blighted trees runs from one-fifth to one-third.

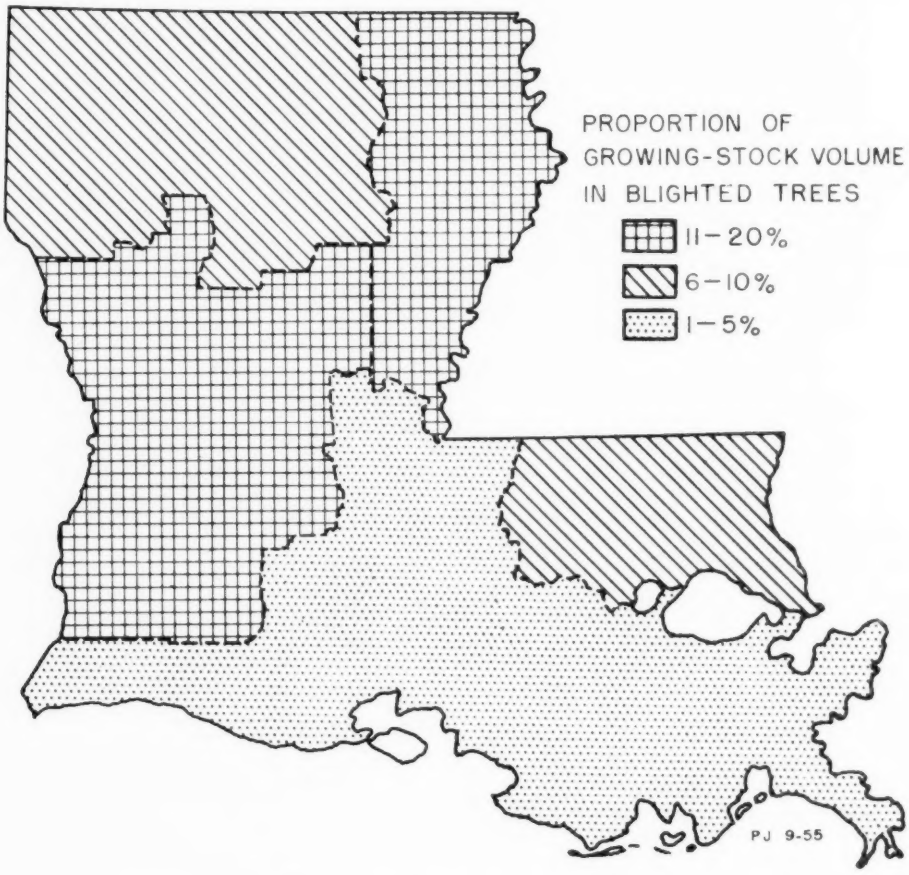

FIGURE 1. Occurrence of sweetgum blight in Louisiana. (Blighted trees are those with 20 percent or more of the fine branches dead or missing in the upper third of the crown).

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Table 1. Number of trees and volume affected by sweetgum blight, by Forest Survey units.

Survey unit	Total sweetgum		Sweetgum with blight [c]	
	Trees [a]	Volume [b]	Trees	Volume
	Million	Million cu.ft.	Percent	Percent
Northwest	50	364	7	8
North Delta	23	202	7	12
Southwest	46	347	6	11
South Delta	30	254	2	2
Southeast	21	121	4	6
TOTAL	170	1,288	5	8

[a] Good and cull trees combined.

[b] Trees with 20 percent or more of the fine branches dead or missing in the upper third of the crown.

Table 2. Relation of tree diameter to blight for the entire state of Louisiana.

D. B. H. class (inches)	Total sweetgum stand [a]	Sweetgum with blight [b]
	Million trees	Percent
6	69	2
8	34	5
10	24	8
12	16	9
14	11	10
16	7	10
18	4	11
20+	5	8
Total	170	8

[a] Good and cull trees 5.0 inches and larger in diameter at breast height.

[b] In good trees 5.0 inches and larger in diameter at breast height.

[c] Trees with 20 percent or more of the fine branches dead or missing in the upper third of the crown.

The Survey was made in 1953 and 1954, with major assistance from the Louisiana Forestry Commission and cooperating private companies. The sampling design was to take a pair of quarter-acre sample plots at each forested intersection of a 3- by 3-mile square grid, except that in certain pine parishes the sampling was intensified. A total of 3,077 pairs of sample plots were taken.

An arbitrary specification of 20 percent or more of the fine branches dead or missing in the upper third of the crown was set up as the criterion for serious blight. Sweetgum trees affected to this degree were classified as blight trees, and their number and volume compiled.

The occurrence of blight by Forest Survey units is shown in Figure 1 and Table 1. Although the disease occurs generally over the State, its intensity varies. The sampling did not disclose the disease in some parishes, while in others up to 34 percent of the volume in good trees 5 inches in diameter and larger was shown to be affected.

Data on mortality due to blight are unavailable, but heavy mortality and reduction in growth are known to be caused by the disease. Table 2 summarizes the relation of blight to tree diameter. Trees in diameter classes above 10 inches have the heaviest proportion of blight--from 8 to 11 percent. These data corroborate a less intensive blight survey made in 1954[3].

Until more is learned about the cause and spread of the blight, no prediction can be made as to long-term implications. Neither can assured control measures be formulated, although a reasonable precaution might be the removal from managed lands of even lightly affected trees, unless there is evidence that the dying has stopped. In view of the fact that some stands show little damage from blight while others are completely ruined, it would be premature to conclude that all sweetgum in affected areas is doomed.

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VIABLE SPORES OF ENDOCONIDIOPHORA FAGACEARUM FROM BARK AND WOOD-BORING BEETLES[1]

W. J. Stambaugh, C. L. Fergus[2], F. C. Craighead and H. E. Thompson[3]

ABSTRACT

A spermatization technique was investigated for utility and adaptability for determining the presence of spores of the oak wilt fungus in or on insects. By this technique, bark and wood-boring beetles (Agrilus bilineatus (Web), Xyleborus spp., Xyleterinus politus (Say) and Pseudopityophthorus spp.) were shown to carry viable spores of Endoconidiophora fagacearum Bretz upon emergence from diseased tree parts. These results, in the light of the habits of these insects, suggest their possible role as agents of overland spread of oak wilt.

INTRODUCTION

Because of certain feeding and breeding habits, several bark and wood-boring beetles were suggested by Craighead (2) in 1952 as possible direct vectors of the oak wilt fungus, Endoconidiophora fagacearum Bretz. Although isolation and transmission attempts followed, no conclusive results were obtained (3). Griswold (6) later obtained positive transmission with Pseudopityophthorus pruinosus (Eichh.) after artificially exposing the beetles to sporulating inoculum, thus indicating that bark beetles associated with diseased material should be considered as possible agents of oak wilt transmission.

Further efforts to isolate E. fagacearum from bark beetles by direct culture methods were unsuccessful. Yount (9) demonstrated the viability of oak wilt fungus spores on the external body surfaces of Nitidulid beetles by culturing the washings from these insects. Viable spores of E. fagacearum have also been recovered from the fecal material of insects which had fed upon the fungus (1, 7).

The growth rate of E. fagacearum in culture is so extremely slow that its presence could be obviated by the majority of contaminating organisms commonly present within or on the bodies of insects. The influence of these contaminating organisms was reduced to a minimum by a spermatization technique which was developed by Jewell (7) to show the viability of conidia of E. fagacearum in the fecal material of Nitidulid beetles. This method has been adapted to determine if certain bark and wood-boring beetles are carrying viable spores of the oak wilt fungus after emergence from diseased trees.

Adult beetles of Agrilus bilineatus (Web.) were collected from cut sections of trees that had wilted in the spring of 1954. The sections were placed in outside cages where the beetles emerged from mid-May to July 1, 1955. Collections of Pseudopityophthorus spp. were made by enclosing bundles of 1955 diseased branch material in hanging canvas and net cages. These insects were obtained in abundance from mid-June to mid-July. Ambrosia beetles were collected throughout the spring and summer as they attacked trees that had wilted late in 1954 and early in 1955. Several species of Nitidulids were collected from mature mycelial and perithecial mats formed during May and September, 1955. Since these insects were in contact with a concentrated inoculum source, they were used primarily to test the efficiency of the spermatization technique.

Collected insects were placed individually or in groups of 5 and 10 into gelatin capsules and stored at 9° C until tested. The majority were tested 3 to 7 days after collection with a maximum storage period of 2 weeks for some collections.

Jewell's (7) method of spermatization included only the use of feces of Nitidulidae; therefore, it was modified in order to determine the possible presence of viable spores in or on insects. The technique is based on the development of fertile perithecia when the receptive mycelium of one compatibility type is spermatized with a spore suspension of the opposite compatibility type. Since suspected insects could be carrying spores of either or both compatibility types, equal numbers of A and B colonies were grown for each test series. Individual Petri dishes were inoculated at four equidistant marginal points with single drops of conidial

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Table 1. Frequency of Nitidulid and Ambrosia beetles carrying viable spores of Endoconidiophora fagacearum from mature mycelial and perithecial mats; Pennsylvania, 1955.

Insect	Month collected	From-mycelial mats			From-perithecial mats		
		Number		%	Number		%
		Tested	Positive	Positive	Tested	Positive	Positive
NITIDULIDAE							
Carpophilus sayi (Say)	May	4	1	25	6	5	83
Colopterus niger (Say)	Sept.	18	14	78			
Colopterus semitectus (Say)	May	5	2	40	7	5	71
Glischrochilus sanguinolentus (Ol.)	May	4	1	25	6	4	67
Total		31	18	58 Av.	19	14	74 Av.
SCOLYTIDAE[a]							
Xyleborus spp.	May	2	1	50	2	1	50
Xyleterinus politus (Say)	May	8	3	37	4	1	25
Total		10	4	40 Av.	6	2	33 Av.

[a] Beetles emerging through mats or pads.

Table 2. Perithecial[a] development of Endoconidiophora fagacearum on Barnett's medium from insects macerated in progressive dilutions of conidial suspension. No replicates.

Insect	Female compatibility	A[b]		A/2		A/10		A/100	
		P	S	P	S	P	S	P	S
Carpophilus sayi (Say)[c]	A	100	24	54	30	15	4	1	5
	B	66	6	15	0	1	0	2	3
Pseudopityophthorus spp.[c]	A	115	28	45	10	12	14	1	2
	B	12	8	22	4	8	0	2	0
Control	A	120	41	27	33	11	18	2	0
	B	85	5	23	9	9	1	1	1

[a] P indicates fertile perithecia. S indicates sterile perithecia.

[b] A represents total conidial concentration of 200, 000 spores in 0.5 ml. of sterile water.

[c] Insects macerated in groups of five.

Table 3. Frequency of bark and wood-boring beetles, tested singly or in groups, carrying viable spores of Endoconidiophora fagacearum from diseased tree parts; Pennsylvania, 1955.

Insect	Source	Tested singly			Tested in groups			
		Number		%	Number			%
		Tested	Positive	Positive	In each group	Tested	Positive	Positive
Agrilus bilineatus (Web)	Early 1954 wilt trees.	28	1	3	5	20	4	17
Pseudopityophthorus spp.	Wilt trees of spring and summer, 1955.	12	0	0	10	58	4	6
Xyleborus spp.	Wilt trees of fall, 1954 and spring, 1955.				5	9	1	11
Xyleterinus politus (Say)	Wilt trees of fall, 1954 and spring, 1955.				5	20	2	10

suspension of one compatibility and incubated for 10 to 12 days. At this time the four colonies in each plate were still widely separated. Barnett's Oak Wilt Agar[4] was used as the culture medium.

Single insects or groups of insects were placed in 0.5 ml. of sterile water in test tubes (10 x 78 mm.) and thoroughly macerated with a sterile glass rod. Transfer of a portion of this suspension was accomplished by a sterile brush which was then used to saturate the mycelium of a single colony in an A compatibility plate. Another sterile brush was used with the same suspension to spermatize a single colony in a B compatibility plate. The last colony in every plate was spermatized with a conidial suspension of opposite compatibility as a check on the A and B isolates being used as females, since considerable variability and change in receptivity was observed with some cultures of the same isolate. By carefully marking and orienting the culture plates, three insects or groups of insects could be tested in two Petri dishes.

The modified spermatization technique was tested before using with large numbers of bark and wood-boring beetles. Since they probably carry fewer spores than insects which feed on mycelial mats, the method should be sensitive enough to permit confidence in a negative result. In addition, macerations of insects might possibly release substances toxic to the spores, or to the female organs, thus inhibiting perithecial formation.

A small number of Nitidulid and Ambrosia beetles were collected from mycelial and perithecial mats and tested, using the above-described procedure. The results (Table 1) indicate that a large number of the insects collected from mats carry the spores of the fungus. In addition, the percentage of Nitidulids carrying viable spores from May perithecial mat collections more than doubled the percentage of insects carrying spores from May mycelial (conidia only) mat collections. Furthermore, of those Nitidulids collected from perithecial mats during May, an average of 21 fertile perithecia developed per positive insect, whereas fertile perithecial development per positive insect from mycelial mats averages 2 for May collections and 20 for September collections.

It is logical to assume from these results that ascospores can function to spermatize female receptive thalli by the spermatization procedure employed herein. Further tests with suspensions of ascospores alone substantiated this assumption. The exact process involved is not known at present, but the capacity of germinating ascospores to form conidiophores and conidia quickly in liquid (4) is highly suggestive.

Ambrosia beetles have frequently been observed to enter wilt trees directly through fresh

[4] The composition of this medium is described in Mycologia 45: 450. 1953.

pads and mats of the oak wilt fungus. A considerable percentage (33 to 40) of these insects removed from sporulating mats tested positive (Table 1), as compared to 10 to 11 percent (Table 3) in group tests of the same insects collected from diseased sapwood as the only known source of inoculum.

To test for possible toxicity of insect macerations, two species of insects not known to have been in contact with oak wilt inoculum were placed in conidial suspensions of varying concentrations and tested by the spermatization technique (Table 2). As a control, the different conidial suspensions only were used to spermatize. The results show that maceration of insects for testing by the spermatization technique does not alter or inhibit subsequent perithecial formation. The results also give some indication of the sensitivity of the method. At the lowest spore concentration (2000 conidia in 0.5 ml. water by dilution) only one, and at most two, fertile perithecia developed per spermatized colony; however, only a portion of the total spore suspension in every test was removed by sterile brush in spermatizing a single mycelial growth.

Final application of the spermatization technique in testing suspected bark and wood-boring beetles showed that a low percentage of Agrilus bilineatus, Pseudopityophthorus spp., Xyleborus spp. and Xyleterinus politus were carrying viable spores of E. fagacearum upon emergence from diseased tree parts (Table 3). There were no mats on any of the trees sampled nor were there any known mats within the near vicinity of insect collection sites. It should be safe to assume that these insects had been in contact with only diseased sapwood as a source of inoculum.

Pseudopityophthorus spp., Xyleborus spp. and Xyleterinus politus were attacking tree parts from which the oak wilt fungus was readily isolated throughout the insect collection period. The wilt trees from which Agrilus bilineatus was collected had been dead for nearly a year and were completely overrun with sapwood rot. All attempts to isolate E. fagacearum from this material failed, yet insects emerging from these trees yielded positive results.

An effort was made to clarify further the possible role of these beetles in oak wilt transmission by direct culture attempts on malt extract agar of apparently healthy tree parts showing signs of their feeding attacks. Although only a few such trees have been sampled, E. fagacearum was isolated from one tree. This tree, a healthy red oak that was felled in the outer perimeter of an oak wilt spot eradication zone, had two small branches completely severed by a twig pruner, Agrilus arcuatus (Say). Further studies of this type are planned.

DISCUSSION

All of the bark and wood-boring beetles tested by the spermatization technique to date have good potentialities as agents of oak wilt transmission.

Agrilus bilineatus, the two-lined chestnut borer, is extremely abundant throughout the range of red and white oak and normally will attack practically all trees that exhibit wilt symptoms by July 1. The beetles emerge the following May and June and immediately go to the tops of healthy, dominant and co-dominant oaks to feed on the leaves.

The oak bark beetles, species of the genus Pseudopityophthorus, are generally abundant in the smaller branches of diseased oak trees. Frequent attacks by these beetles in healthy trees have been observed where breeding was abundant in nearby wilt trees.

The Ambrosia beetles are of interest primarily as a possible vector of the oak wilt fungus to trees with large, exposed areas of dead sapwood as a result of damage due to fire, logging, lightning strikes, etc. These beetles bore through the bark into the sapwood of diseased trees in the early spring and throughout the summer. Approximately 6 weeks after constructing their egg galleries, the new brood of beetles emerges and flies to other dying trees, scarred living trees, or green logs to repeat the cycle.

All of the beetles previously mentioned could come into contact with sporulating mats, either upon entering or emerging from diseased trees. None of these insects have ever been observed actually to feed in situ upon mats of the oak wilt fungus. Since E. fagacearum is known to produce conidia in the vessels of diseased trees (8), it could be assumed that the majority of these insects probably obtain oak wilt inoculum through their feeding and breeding activity in the sapwood of wilt trees.

In Pennsylvania, some spread of oak wilt has been observed 50 to 150 feet beyond the nearest known infected tree. In many cases this spread appeared at a distance well beyond any apparent possibility of root grafting. If these insects are capable of transmitting oak wilt to healthy trees, their great abundance and rather limited movement after emergence from diseased trees may explain this type of spread.

Although oak wilt transmission attempts with bark and wood-boring beetles have failed in

previous years, the fact that these insects are now known to be carrying viable spores of E. fagacearum suggests the immediate need for further transmission studies. Continued testing of suspected insect vectors by means of the modified spermatization technique is also planned.

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RADIAL PENETRATION OF THE OAK-WILT FUNGUS INTO THE BOLES OF DISEASED TREES

T. W. Jones and T. W. Bretz[1]

It has been reported that the oak-wilt fungus (Endoconidiophora fagacearum Bretz) is limited to the outer three annual rings of sapwood in wilt-infected trees. Henry and Riker (1) recovered the fungus from naturally infected trees as deep as the 2-year-old summer wood; Young (3) reported that the fungus was restricted to the outer one-fourth inch of sapwood and that it was not recovered from heartwood; and Tehon et al. (2), isolating from segments of increment cores from wilting trees, recovered the fungus from the current annual ring of sapwood only. In each case cited, isolations were made from actively wilting or recently wilted trees.

Investigation of the radial penetration of the oak-wilt fungus in the boles of standing wilt-killed trees was made in southern Missouri during February and March of 1954. The 11 trees selected for the study displayed foliar symptoms of oak-wilt and the presence of the fungus had been confirmed by culturing during the preceding summer. The trees were of the red oak group and ranged from 5 to 16 inches in d.b.h. Eight of the trees were producing mats at the time of the study and the other three appeared to be in a suitable condition for mat production.

Increment cores were removed at 6-inch intervals around the circumference of each tree at 2-foot height intervals, from stump level to the base of the crown. Each core was divided into 4 subsamples consisting of (a) the 3 annual rings of sapwood adjacent to the cambium, (b) the 4th, 5th, and 6th annual rings of sapwood from the cambium, (c) the 3 rings of sapwood adjacent to the heartwood, and (d) the 3 rings of heartwood adjacent to the sapwood. Isolation of the oak-wilt fungus from each of these subsamples was attempted.

The oak-wilt organism was recovered from only 148 of the 2,216 subsamples taken. Secondary fungi were prevalent in most of the cultures. Fifty-six of the positive oak-wilt isolations were from the outer 3 annual rings of sapwood, 65 from the 3-, 4-, and 5-year-old sapwood, and 27 from the 3 rings of sapwood adjacent to the heartwood. Maximum depth of recovery of the fungus was the 10th annual ring from the cambium and 32 mm. from the cambium. The organism was not recovered from the heartwood.

The average sapwood moisture content, based on oven-dry weight, at place of fungus recovery was 71.4 percent, and the minimum was 52.1 percent.

On the basis of the earlier work cited, the oak-wilt fungus is apparently limited to the outer sapwood of infected trees during and shortly after the period of foliar symptom expression. However, the results of this study indicate that by the time the killed tree is in a condition suitable for fungus mat production, the organism may have invaded any part of the sapwood.

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A NOTE ABOUT BREAKING DORMANCY OF OAK IN THE GREENHOUSE

Charles L. Fergus[1]

The development of efficient, simple and inexpensive methods of breaking the dormancy of oak species has practical value in greenhouse studies of oak wilt and other oak diseases. By their use, oaks in green leaf could be obtained any time of the year for studies of oak diseases which involve the foliage.

The methods tried were exposure to ethylene chlorohydrin, clipping of all the terminal buds, and exposure to low temperatures (20° and 40° F).

Scrub (Quercus ilicifolia Wang.), scrub chestnut (Q. prinoides Willd.), white (Q. alba L.), red (Q. borealis Michx.), scarlet (Q. coccinea Muench.), and black oak (Q. velutina Lam.) were the species studied. The seedlings had been grown from acorns in the greenhouse and were approximately 5 years old. They had been placed outdoors each summer and were brought back into the greenhouse after becoming dormant. Six seedlings of each species were left outside as outdoors controls. In addition, six seedlings of each species were set aside as controls in the greenhouse.

On the first of November, six seedlings of each species were exposed to ethylene chlorohydrin in a large air-tight container for 48 hours. The concentration used was 18 ml. of 40% per 100 liters of space. They were then placed on benches in the greenhouse. Eighteen days after treatment the lateral buds of all the treated oak species began to open. This was 4 months before the buds of the untreated greenhouse controls opened and 6 months before the buds of the outdoors controls opened. The opening buds developed rapidly to mature, normal leaves and shoots. Four weeks after the exposure to the chemical, leaves and shoots were over 3 inches long. An automatic hygrothermograph was used to determine the temperature and relative humidity in the greenhouse for 2 weeks during the course of the experiment. The maximum temperatures were: day 86°, night 68°; minimum temperatures were day 68°, night 66° F. Relative humidity varied from 50 to 76 percent, dependent upon temperature and time of watering of plants.

None of the terminal buds of the ethylene chlorohydrin-treated oaks leafed out. Examination showed that the buds had been killed by the chemical. The possibility existed that the injury to the seedlings had evoked bud opening. Therefore, the terminal buds of one-half of the control trees were pruned off on December 1. The lateral buds of these trees opened at varying time intervals after pruning depending upon the species involved. For example, the lateral buds of red oaks began to open January 1, of white oak January 14, but those of scrub oak did not open until the untreated controls (March 14).

Exposure to low temperatures (20° and 40° F) in automatically controlled temperature rooms for 22 days caused buds of white, red, and black oak to start opening 2 months after removal from the low temperature and placing in the greenhouse. The seedlings used for this experiment had been dug up in November, and the roots balled and burlapped. Some trees were killed by the exposure to 20°.

Non-treated seedlings of the same age and condition did not leaf out in the greenhouse until the second week in March. The same species outside the greenhouse leafed out during April-May.

In summary, exposure to ethylene chlorohydrin was the most successful and convenient method of those tested to break the dormancy of oaks. Kramer[2] used this chemical in 1934 to break the dormancy of red and white oak successfully. The tests reported here show that other oak species will also respond to ethylene chlorohydrin, thus enabling the worker to obtain green leaves for foliage symptom studies at times when they are not ordinarily available. Only one concentration was used and it killed terminal buds. It is possible that a lower concentration would stimulate the buds to open without such killing. Exposure to low temperatures caused the oaks to open earlier than the untreated checks, but the method was not so successful as exposure to ethylene chlorohydrin. Clipping the terminal buds of red and white oak stimulated the lateral buds to open earlier than the controls, but not all species were affected similarly.

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PERFORMANCE OF WILT-RESISTANT MIMOSA TREES IN HIGH-HAZARD AREAS

E. Richard Toole

The vascular wilt of the mimosa or silktree (Albizzia julibrissin Durazz.), which was first reported from Tryon, North Carolina, in 1935, has destroyed many mimosa trees in the Southeast. The disease is caused by Fusarium oxysporum f. perniciosum (Hepting) Toole.

In 1939, a number of clones of Albizzia were selected for their resistance to the wilt and propagated vegetatively[1]. In the spring of 1949, trees from the most promising clones were planted in nine areas where mimosas had died of wilt.

Planting locations were Silver Spring, Maryland, Richmond, Virginia, Raleigh and Tryon, North Carolina, Clemson, Columbia, and Wisacky, South Carolina, Athens, Georgia, and Auburn, Alabama. One or more trees of each of nine or ten different clones were planted at each location, except that the planting at Silver Spring consisted solely of 12 trees of a single clone. Trees were 1 year old and 2 to 4 feet high at the time of planting. Many of the plantings were near the stumps of wilt-killed trees.

In the fall of 1954, after six growing seasons, 65 percent of the trees were still alive (Table 1). Some had reached a height of 20 feet and a diameter of 6 inches. Only one of the 116 trees is known to have died of wilt. Most of the mortality was attributable to drought or mechanical injury. At Columbia, South Carolina, and Richmond, Virginia, however, information as to the cause of death was not available for all trees and it is therefore possible that some died of wilt.

Table 1. Survival in 1954 of wilt-resistant mimosa plantings made in 1949.

Clone[a]	Places planted	Trees planted	Alive through 1954	Killed by wilt[b]
2-608	8	9	5	0
2-610 ("Charlotte")	7	9	7	0
2-612	7	10	6	0
25-328	7	7	6	0
25-329	8	8	6	0
25-333	8	14	10	0
27-64 ("Tryon")	1	4	4	0
27-65	8	19	14	0
27-67	9	28	21	0
46-72	8	8	4	1

[a] The first number denotes the seed source, and the second number the parent tree from which the cuttings were made. The named clones are available from certain nurseries.

[b] Information is incomplete as to cause of mortality at Columbia, South Carolina, and Richmond, Virginia; some trees at these places may have died of wilt. One or two trees of each clone except 25-328 and 27-64 were planted at each of these places.

Since susceptible mimosas planted in wilt-infested soil will rarely survive even 1 year, the results of this test demonstrate the wilt-resistance of these clones.

Two of the clones were released to the nursery trade in 1949 under the names "Tryon" and "Charlotte," and are available at certain nurseries.

DELTA RESEARCH CENTER, SOUTHERN FOREST EXPERIMENT STATION, FOREST SERVICE, U. S. DEPARTMENT OF AGRICULTURE, IN COOPERATION WITH MISSISSIPPI AGRICULTURAL EXPERIMENT STATION

[1] Toole, E. R., and G. H. Hepting. Selection and propagation of Albizzia for resistance to Fusarium wilt. Phytopath. 39: 63-70. 1949.

A DESCRIPTION OF CORNELL TEMPERATURE TANKS

J. M. Ferris[1], Bert Lear[2], A. W. Dimock[3], and W. F. Mai[3]

In studies of plant diseases which involve root attacking pathogens it is often desirable to control soil temperatures within well defined limits. This problem has been solved at Cornell University by adapting stock-item milk coolers to serve as temperature tanks. Soil is put in watertight containers which are placed in a water bath. The temperature of the water bath can be maintained at any desired temperature, with a deviation of $\pm$ 2° F. The temperature tank is relatively inexpensive, simple to construct, and a complete unit in itself.

This type of tank was first assembled in 1949, under the direction of Bert Lear at the Golden Nematode Research Laboratory, Long Island, New York. Improvements were incorporated when a second group of tanks was constructed in a Plant Pathology greenhouse in Ithaca under the supervision of A. W. Dimock. Additional improvements were added to the Long Island tanks by the senior author.

The milk cooler is placed on a wooden frame so that it is supported at least 4 inches off the floor. This elevation makes it easier to drain the tank for cleaning. A standpipe can be screwed to the drain outlet of the tank. This pipe serves as a drainpipe when it is turned down and as an automatic water level control when turned up in a vertical position. The compressor unit is disconnected and removed from the lid of the tank. The lid is then detached and discarded. The compressor unit is placed beside the tank so that the cooling fan has adequate ventilation. In a large greenhouse with side ventilating windows, ventilation for the compressor unit is not a problem. In a small greenhouse at the Long Island laboratory it was found that a ventilation hole had to be cut in the wall of the house opposite the cooling fan of the compressor unit as an aid to air circulation.

The compressor is connected to the milk cooler in the usual manner, except that the electric cord for the unit is plugged into the outlet marked "refrigeration" on the utility box (Diagram 2). The operation of the refrigerating unit is thus controlled by the thermoregulator through the mechanically locking relay in the utility box. The normal low temperature cut-off of the compressor may be left in operation for safety.

The electric stirrer is assembled as shown in Diagram 1. The upper fan blade forces air through the electric motor, keeping it cool during operation. The lower fan, which agitates the water, must have two-thirds of each blade removed so that excessive drag will not overload the motor. This small fan blade still gives adequate stirring of the water in the tank. The electric cord for the stirrer is plugged into the outlet marked "utility" on the utility box.

The wiring details for the temperature regulating mechanism used at the Long Island laboratory are given in Diagram 2. All of the items in this diagram, except the thermoregulator, should be placed in an electric utility box. This box is then mounted on the side of the tank (Fig. 2). A mechanically locking relay is employed to eliminate chatter of the relay in the refrigerating circuit as the water in the tank warms to a point where cooling is necessary.

The stirrer, heater, and thermoregulator can all be mounted on a board at one corner of the tank (Figs. 1, 3). In this manner the units will require the least amount of space and all controls are consolidated.

Before a temperature tank is used, all surfaces of the tank which will come in contact with water should be painted with a horticultural asphalt paint. This will retard rust and corrosion of the tank.

Tanks such as the ones described here will hold 15 1-gallon or 24 1/2-gallon glazed pottery crocks. A wooden rack supports these crocks near the top of the tank. The rack is constructed so that it can be removed easily when the tank has to be cleaned and repainted. At Ithaca the racks are supported on short flanges welded on four iron straps hung over the sides of the tanks (Diag. 3). Brackets are welded to the outer leg of the two straps at the back of the tanks to support the compressor and control panel (Fig. 4).

The following is a list of the materials necessary for the construction of a temperature tank similar to those at the Golden Nematode Research Laboratory, Long Island:

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[1] Research Assistant in Plant Pathology, Cornell University.

[2] Assistant Nematologist, Department of Plant Nematology, University of California, Davis.

[3] Professor of Plant Pathology, Cornell University.

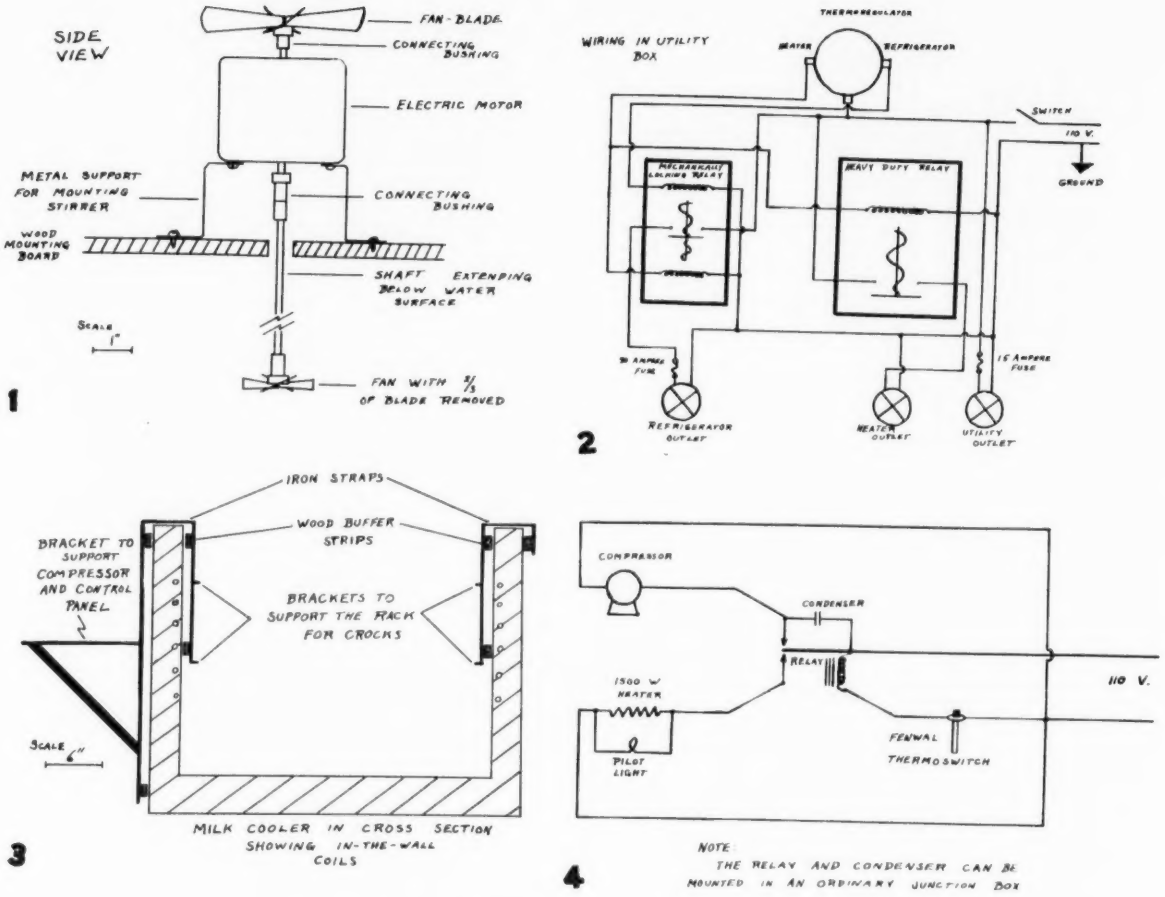
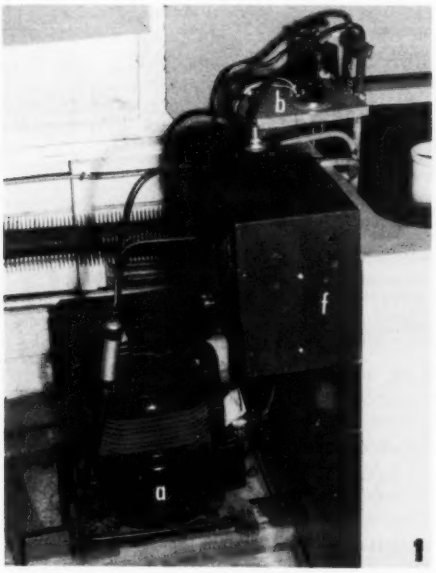
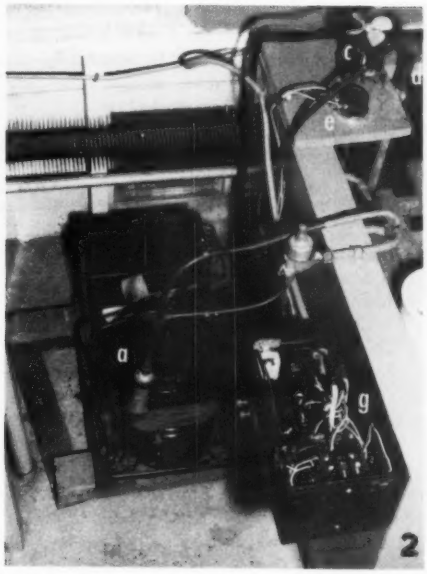
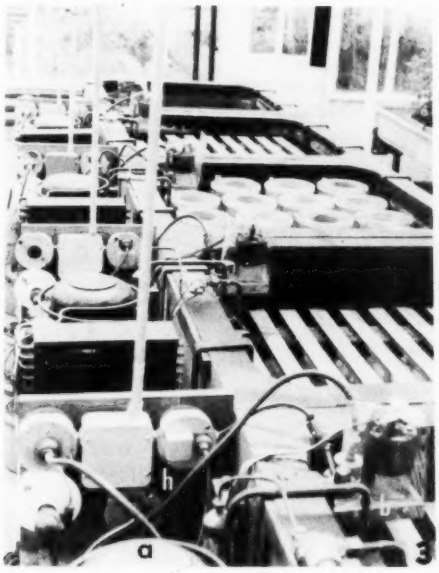
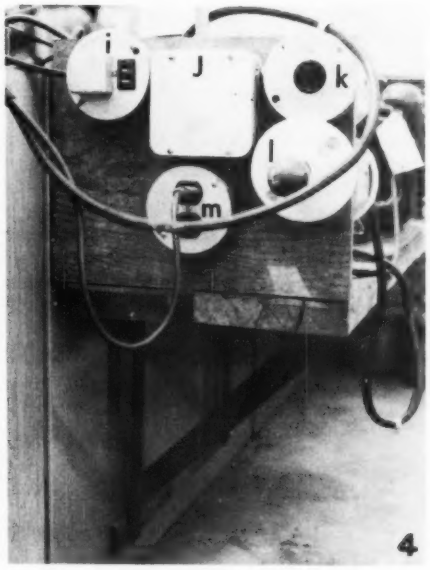


DIAGRAM 1. Stirrer assembly. DIAGRAM 2. Long Island tank wiring. DIAGRAM 3. Supporting rack in Ithaca tank. DIAGRAM 4. Ithaca tank wiring.









FIGURES 1 and 2. Temperature tank at Long Island laboratory.
FIGURE 3. Temperature tanks in Plant Pathology greenhouse, Ithaca. FIGURE 4. Detailed view of control panel (h in Fig. 3).
a - compressor; b - mounting for stirrer, heater and thermoregulator; c - stirrer; d - heater; e - thermoregulator; f - electric utility box; g - arrangement of switch, relays and wiring inside utility box; h - control panel; i - refrigerator outlet; j - junction box with relay inside; k - heater outlet; l - pilot light for heater circuit; m - utility outlet for stirrer.

Island tank wiring. DIAGRAM 3. Supporting rack in these tank. DIAGRAM 4. Ithaca tank wiring.

1. -- 4-can milk cooler, top opening, with in-the-wall refrigerating coils[4] and a 1/3 to 1/2 horsepower compressor unit, vertically-mounted, direct drive (similar to model VD-S4 manufactured by Esco Cabinet Co., West Chester, Pa.; this model can be equipped with a 1/2 h. p. model 6D2CRA Kelvinator compressor). The compressor unit and/or the tank, without the lid, may be purchased separately.

2. -- Small electric motor (115 v. A. C., shaded pole, 1740 rpm, 1/60 h. p., dual shaft), two 3-inch four-bladed fans, 18-inch metal shaft, and bushings for assembling the stirrer. Assembled stirring units are available, but are more costly.

3. -- 115 volt, 1500 watt immersion heating element (similar to one manufactured by E. L. Wiegand Co., 7500 Thomas Blvd., Pittsburgh 8, Pa.). Other, lower wattage, immersion heating elements would be satisfactory.

4. -- bimetal (3 terminal) thermoregulator (similar to "Quickset" manufactured by American Instrument Co., Silver Spring, Md.).

5. — Heavy duty relay (double pole single throw, double break, 25 amp., coil 115 v., 60 cycle similar to the G. E. contactor).

6. -- Mechanically locking relay (latching relay, double throw, normally open, with back contact, both coils 110 v. A. C. -- similar to one manufactured by Struthers Dunn, Inc., Philadephia, Pa.).

7. -- Electric utility box, 3 outlets, two fuse holders, and a heavy duty switch.

Although the temperature control equipment described above is complicated, it has the advantage that when the water in the tank is at the proper temperature, neither the heater nor the refrigerator will be operating. The tanks in Ithaca utilize a slightly different method of temperature control. The following items are substituted for materials listed under numbers 4-7 above:

4'. -- Fenwal standard all-purpose thermoswitch.
5'. -- Inexpensive silver-contact, double throw relay.
6'. -- Small junction box.

Wiring details for this type of temperature control are given in Diagram 4. If necessary a 0.001 to 0.01 mfd condenser may be shunted across the compressor contacts of the relay to reduce chatter. An advantage of this set-up is that it is cheaper than the one used on Long Island. It has the disadvantage that, unless either heating element or compressor is disconnected, one or the other is always on, i.e., regardless of the temperature setting, the units are on alternately. If this type of set-up is being operated definitely above or below the greenhouse temperature range, the heater or compressor which would not be needed could, of course, be unplugged.

DEPARTMENT OF PLANT PATHOLOGY, CORNELL UNIVERSITY, ITHACA, NEW YORK

[4] In the original tanks constructed in 1949, three types of cooling coils were used: 1)--coil-in-rack inside the tank, 2)--drop-in cooling unit, and 3)--coil-in-wall unit. The coil-in-wall unit was selected as most satisfactory because less of the tank area was used for equipment.

MEADOW NEMATODES IN STRAWBERRY PLANTINGS IN MASSACHUSETTS

A. C. Goheen and J. S. Bailey

Summary

Meadow nematodes (Pratylenchus spp.) were found in 20 of the 24 strawberry root samples from 8 counties in Massachusetts. They were encountered far more commonly than root-knot nematodes (Meloidogyne hapla) on strawberries in that State. In two cases, large populations of meadow nematodes were associated with severe black-root rot. In other cases severe black-root rot occurred in fields where the meadow nematode population was not large.

Interest in the role of meadow nematodes (Pratylenchus spp.) in the strawberry black-root rot disease is increasing (2, 3). The results of a survey of strawberries in Massachusetts for the presence of meadow nematodes may be of interest to persons working on black-root rot and nematode problems.

Table 1. Meadow nematode counts from root samples from 24 strawberry plantings in Massachusetts, October 1953.

County of origin	Variety sampled	Black-root rot rating	Nematodes/gram of feeder rootlets
Middlesex	Robinson	Severe	800
Plymouth	Sparkle	Severe	289
Barnstable	Sparkle	Medium	133
Essex	Catskill	Medium	74
Essex	Robinson	Light	74
Hampshire	Robinson	Light	67
Hampden	Temple	Light	63
Essex	Sparkle	Light	52
Hampshire	Everbearer	Severe	50
Hampshire	Sparkle	Light	50
Plymouth	Sparkle	Light	40
Berkshire	Superfection	Medium	34
Franklin	Robinson	None	34
Hampshire	Howard 17	Light	19
Middlesex	Catskill	Medium	19
Plymouth	Sparkle	None	15
Barnstable	Howard 17	Severe	14
Plymouth	Howard 17	Light	8
Hampden	Howard 17	Light	1
Barnstable	Howard 17	Severe	1
Hampden	Robinson	Medium	0
Barnstable	Howard 17	Light	0
Berkshire	Catskill	Moderate	0
Franklin	Fairfax	None	0

During October 1953 strawberry root samples from 24 plantings scattered through 8 of the 14 counties of Massachusetts were obtained through the cooperation of the county agents. The agents rated the plantings for black-root rot at the time they took the samples. These ratings were: disease-free roots, or light, medium, or severe root rot. Each sample was composed

[1] Plant Pathologist, Horticultural Crops Research Branch, Agricultural Research Service, U. S. Department of Agriculture

[2] Associate Research Professor, Massachusetts Agricultural Experiment Station, East Wareham, Massachusetts.

of the entire root system of approximately 5 plants selected at random from each field. The roots were placed in polyethylene bags and forwarded to the junior author at East Wareham, Massachusetts. As soon as all the samples were assembled, they were brought to Beltsville, Maryland and examined for root nematodes. All samples were examined in 10 days or less from the time they were taken.

Prior to any microscopic examinations the roots were checked for symptoms of the Northern root-knot nematode, Meloidogyne hapla. The samples were then examined by comminuting weighed amounts of feeder rootlets taken from all the plants in each sample in a Waring Blendor and estimating the number of Pratylenchus recovered in known aliquots of the material collected on a 200-mesh sieve as described by Goheen (1) in a previous paper.

Root-knot nematode galls were found in 2 of the 24 samples. Meadow nematodes were recovered from 20 of the 24 samples. The number of meadow nematodes per gram of roots, as well as the county agents' black-root rot rating, and the county of origin of the plants are recorded in Table 1 for each of the 24 samples.

The greatest numbers of meadow nematodes were found in two samples from fields that were rated as severely affected with black-root rot. Meadow nematodes were not found in all fields that were so rated, however. In one sample from such a field it was difficult to find any meadow nematodes. Pratylenchus spp. were found in several root samples from fields that were rated free from black-root rot or only lightly affected. Since the rating of these fields was based on a single examination and the subsequent black-root rot condition of these fields was not evaluated, the significance of these observations is not known.

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1. Goheen, A. C. 1954. Meadow nematodes on raspberries and blackberries. Plant Dis. Reptr. 38: 340-341.
2. Klinkenberg, Caroline H. 1953. Zwart wortelrot van aardbein. Tijdschr. over Plantenziekten 59: 261-262.
3. _____. 1955. Nematode diseases of strawberries in the Netherlands. Plant Dis. Reptr. 39: 603-606.

HORTICULTURAL CROPS RESEARCH BRANCH, AGRICULTURAL RESEARCH SERVICE, U. S. DEPARTMENT OF AGRICULTURE, AND MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION, EAST WAREHAM, MASSACHUSETTS

UNUSUAL RECORDS AND OTHER BRIEF NOTES ON PLANT DISEASES

VERTICILLIUM WILT OF MELONS

By Stephen Wilhelm and Eugene E. Stevenson

For the past several years the Verticillium disease of melon caused by Verticillium albo-atrum Reinke & Berth. has caused repeated losses to growers in the Brentwood and Patterson areas of the San Joaquin valley of California. Three years' observations and laboratory studies by the senior author concur in all important respects with those of Kendrick and Schroeder, published more than 20 years ago[1].

The Cassaba and Persian varieties of Cucumis melo L. are the most susceptible of the melons grown in these areas, and the disease causes great losses to growers. Not infrequently almost the entire production of Cassaba has been worthless. The Crenshaw melon and cantaloupe, though frequently seriously affected, usually yield something. Honeydew is tolerant of the Verticillium, though laboratory studies have shown that the vascular tissues are pervaded by the fungus. As in other annual and perennial crops except fruit trees, the Verticillium disease in melons is primarily a mature-plant disease. It does not affect the seedlings, but withers the mature plant at the time that expectations for a good crop are high.

Melons, especially Cassaba and Persian, planted in 1954 about April 15 in the areas mentioned showed wilt symptoms by June 30. By July 15, when fruit was approaching maturity, the plants collapsed. The large crown leaves wilted, developed extensive marginal and interveinal necrosis, and with hot weather dried quickly while still retaining their green color. The exposed immature melons were sunscalded. Verficillium wilt, in the early stages, is a crown blight, and growers frequently use that term to designate it.

The vascular tissues of affected plants show a distinct yellow color which contrasts sharply with the glistening white of healthy bundles. The Verticillium was isolated readily from the vascular tissues of blighted plants, both from near the crown and from several feet distant in runner shoots.

The most serious outbreaks of Verticillium wilt in melons have been on land cropped repeatedly to melons or previously planted to tomatoes. Eighteen different isolates of Verticillium from the various melons listed above, including Honeydew, were pathogenic to Pearson tomato in greenhouse tests.

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[1] Kendrick, James B., and Floyd R. Schroeder. 1934. Inoculation tests with Verticillium wilt of muskmelons. Phytopath. 24: 1250-1252.

PUCCINIA DACTYLIDIS ON ORCHARD GRASS IN NEW YORK

By D. A. Roberts and R. P. Murphy

The uredial stage of a leaf rust fungus has been observed since about 1950 on orchard grass, Dactylis glomerata L., in plant breeding spaced-plant nurseries in New York. Each year, most leaves of some plants have been killed, especially in late summer and early fall. Seed yields of severely affected plants undoubtedly have been reduced. Little evidence of this leaf rust has been found in broadcast-seeded plots managed for hay or pasture purposes.

Occurrence of both telial and uredial stages of the fungus in 1955 made possible its identification. Uredia lack paraphyses, are amphigenous, circular to oblong, pulverulent, and light brown. Urediospores are globose, echinulate, 24 to 28 μ wide, and 25 to 30 μ long; have hyaline walls approximately 1.5 μ thick; and have from 5 to 7 scattered, obscure germ pores. Telia are amphigenous, circular to oblong, exposed, and black. Teliospores are 2-celled, oblong-clavate, 16 to 22 μ wide, 42 to 47 μ long, and slightly constricted at septa. Teliospore walls are approximately 2 μ thick at sides, and 4.5 to 7 μ thick at apices. Usually apices of teliospores are truncate, but a few spores with rounded apices occur. Pedicels are 1 to 2 times as long as teliospores. Pycnial and aecial stages have not been found.

The fungus has been identified as Puccinia dactylidis Gäum.[1], and is reported here for the first time as occurring in the United States. Specimen 43796 is filed in the Plant Pathology Herbarium, Cornell University, Ithaca, New York.

DEPARTMENT OF PLANT PATHOLOGY, CORNELL UNIVERSITY, ITHACA, NEW YORK

[1] Gäumann, E. 1945. Zur Kenntnis einiger schweizerischen Rostpilze. Ber. Schweiz. Bot. Gesell. 55: 70-80.

OCCURRENCE OF DUTCH ELM DISEASE IN TENNESSEE

By H. E. Reed

American elm trees on The University of Tennessee campus at Knoxville and in the vicinity are showing typical symptoms of Dutch elm disease. Specimens obtained from two such trees when plated out gave the causal fungus, Ceratostomella ulmi Buis. (Graphium stage).

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SOME TREE DISEASES IN TENNESSEE

By E. L. Felix

Oak wilt, caused by Endoconidiophora fagacearum, was positively identified in the following specimens submitted in August by John E. Wiggins, forester, U. S. Soil Conservation Service: scarlet oak from Washington County, blackjack oak and southern red oak from Rhea County. The latter is believed to be a new area for this disease. Decidedly characteristic symptoms were present and the fungus was successfully isolated from twigs or chips on Barnett's medium. Identification was verified by J. O. Andes.

Wilt of the painted maple (Acer mono), caused by Verticillium albo-atrum, was found on the Experiment Station grounds.

A Juniper planting identified by A. C. Koelling, adjacent to an affected apple and pear orchard, is exhibiting striking differences in susceptibility to rust (Gymnosporangium spp. probably G. clavipes, and G. juniperi-virginianae), which greatly impairs the ornamental value of some of them:

Very susceptible (galls exceedingly numerous) -- Juniperus virginiana hort. var. canaertii and elegantissima)(?) gold tip form.

Moderately susceptible (galls numerous) -- J. virginiana hort. var. pyramidiformis.

Slightly susceptible (galls very few) -- J. virginiana hort. var. glauca.

Immune (gall-free) -- J. chinensis hort. var. pfitzeriana and J. horizontalis hort. var. plumosa.

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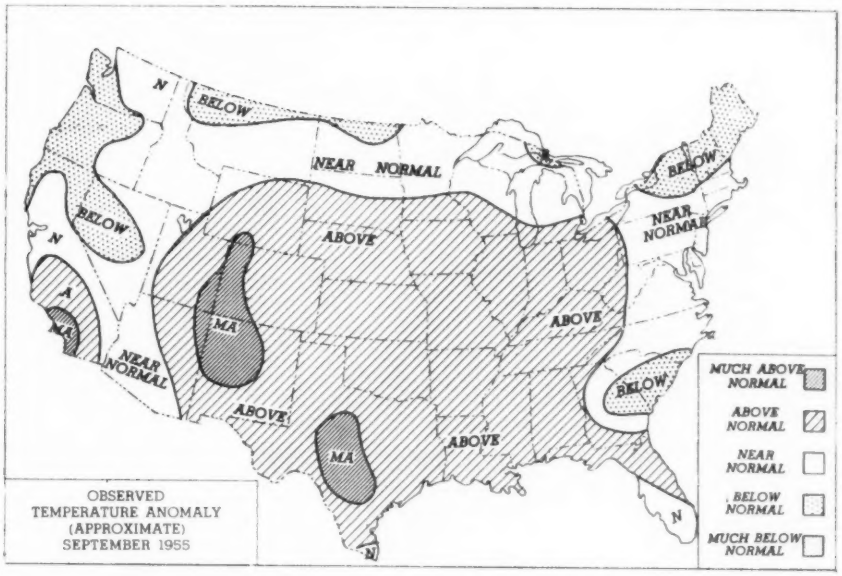
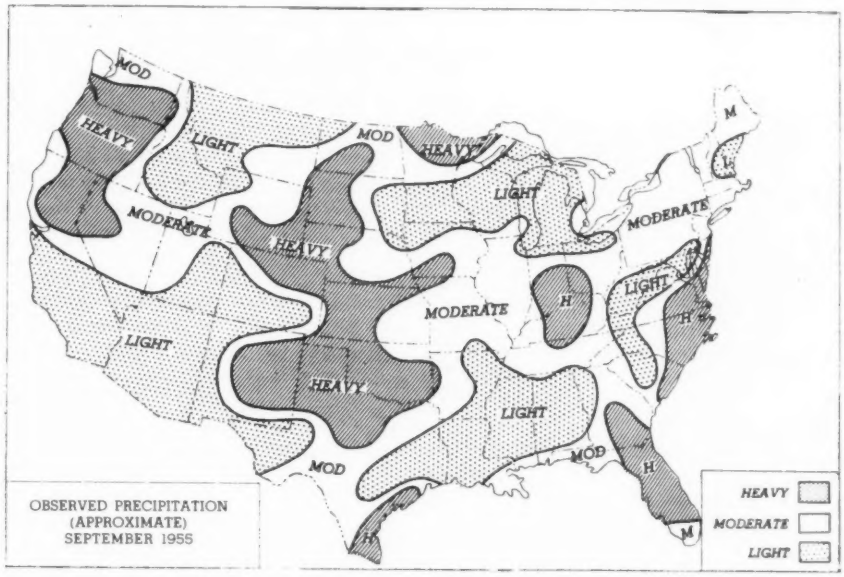
CORRECTIONS

In the August 15, 1955 Reporter, page 648, Table 1, Liquid 365 should read Liquid 364. Liquid 365 (3.39% phenyl Hg acetate plus 2.35% ethyl Hg acetate) is more effective than 364 (5% phenyl Hg acetate plus 0.95% ethyl Hg acetate) which has been discontinued.

In the article entitled "Effect of streptomycin formulations on angular leaf spot in cucumber" in the October 15, 1955 Reporter, the last sentence of the first paragraph on page 735 should be changed to: "The amount of infection on plants sprayed with the antibiotic 1, 2, or 3 days after inoculation..."





The terms used in the accompanying maps, which define the ranges of temperature and precipitation, are numerical class limits. These are based on a statistical analysis of past records through which is determined the normal frequency of occurrence of temperatures and precipitation at various times of the year for different locations. For temperature the classes above, below, and near normal are so defined that they each normally occur one-fourth of the time; much above and much below normal, one-eighth of the time Precipitation is depicted in terms of light, moderate, and heavy, each class normally occurring one-third of the time and thereby having equal probability of occurrence. These maps graphically represent only the general trends and give the country's weather picture at a glance. For quantitative studies, where monthly mean temperatures and actual precipitation records are needed for a given time and place, other publications of the Weather Bureau should be consulted. P. R. M.

MANUSCRIPTS FOR THE PLANT DISEASE REPORTER

(See also PDR 35: 121-122; 36: 214, 494)

(1) GENERAL: The Reporter page measures 9 inches long with the heading or 8 3/4 inches for the text part, by 6 inches wide. The copy is typed on a larger page, 11 1/4 inches of text or 12 inches overall in length by 8 inches in width, and reduced 25 percent in the photographic process of reproduction. Illustrations or tables larger in either dimension will take a correspondingly greater reduction. Only one size of type is available for text, footnotes, or tables.

(2) MANUSCRIPTS should be the original ribbon copy, not carbons, clearly typed and double-spaced throughout, including tables, footnotes, and bibliographies. (Note -- only one copy is needed.) Footnotes should be typed at the bottom of the page.

(3) ABSTRACTS are requested for all except very short articles. (PDR 38: 316).

(4) CAUSES OF DISEASES should be named. For bacteria, fungi, nematodes, etc., give the Latin name of the organism; for viruses either or both the accepted common name of the virus or a Latin name if you prefer it and there is one; for non-parasitic diseases state the causal factor if it is known. If the cause of a disease has not been determined say so. (PDR 36: 494).

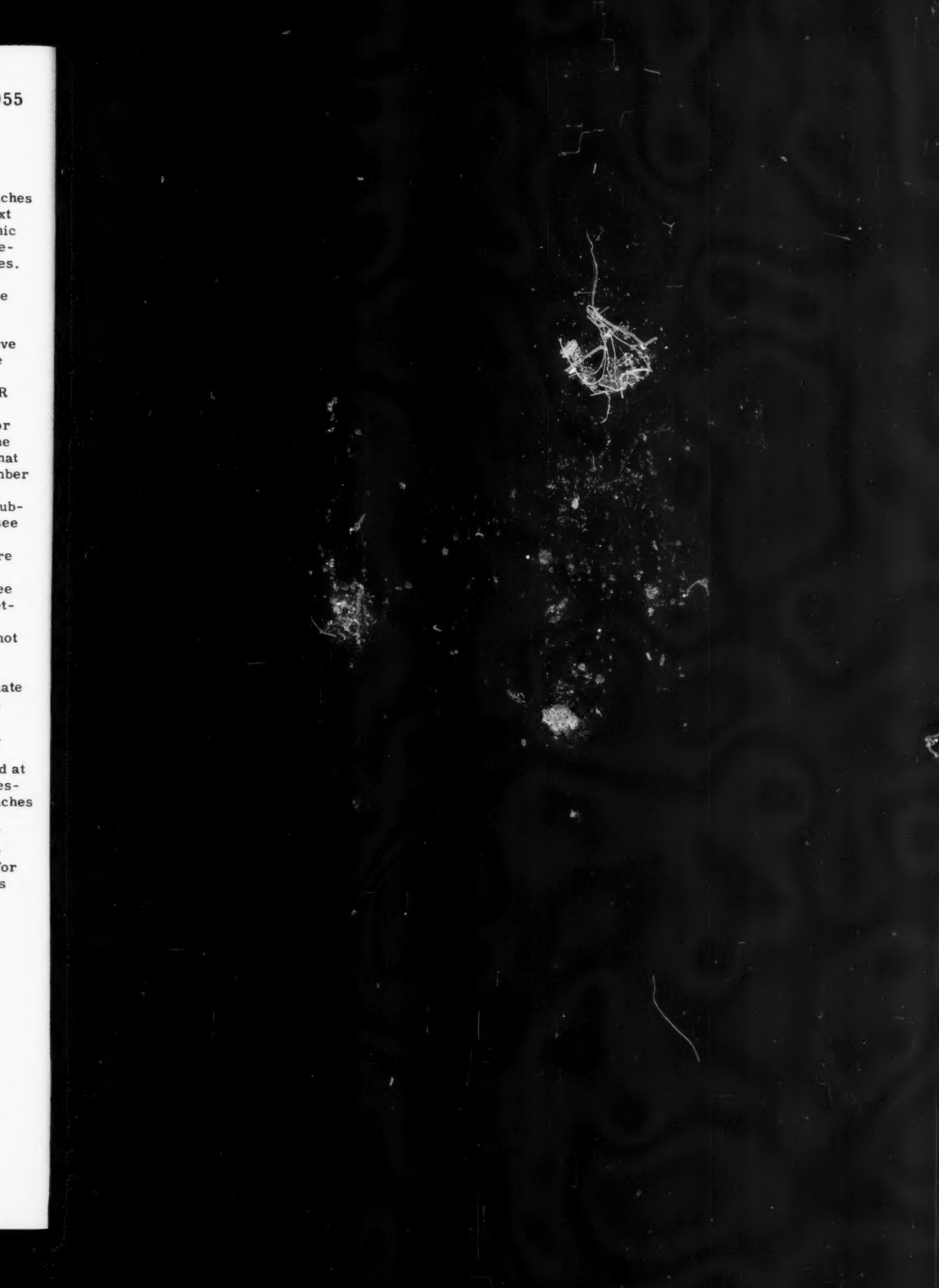
(5) LITERATURE REFERENCES should be given in alphabetical order and numbered for citation in the text. We follow the AIBS suggestion of placing the year of publication after the author's name. Please check your titles carefully since we cannot do it for you. Be sure that text citations and bibliography agree; that foreign-language references are correct; that number or month is cited for periodicals that are not paged consecutively throughout the volume.

(6) NAMES OF FUNGICIDES should be given according to the suggestions that will be published in Phytopathology before long, and later repeated in the Reporter. In the meantime see PDR 35: 122.

(7) ILLUSTRATIONS should be sent to us unmounted. To prevent mistakes, write figure numbers on the back, and mark the top of each print when necessary. A sketch can show a preferred arrangement but please keep in mind page size, shape, and standard reduction (see above under General), and remember that figure titles and legends are part of the page. Lettering should be clear and large enough to be legible after reducing. Drawings, maps, and graphs can be photographs or originals, but should be finished and ready for reproduction, not just sketches.

(8) TABLES should be carefully thought out with particular attention to the Reporter's limitations in reproduction. Make titles and headings definite and self-explanatory. Designate footnotes in tables with superscript lower-case letters. Be sure that text discussion agrees with the data in the table. Do not abbreviate names of crop varieties.

(9) REPRINTS cannot be supplied since there is no way in which we can be reimbursed. However,

(10) The MULTILITH PLATES from which reprints can be made will be sent if requested at the time the article is submitted. The press size of these plates used for the Reporter is designated as small -- maximum image 9 1/2 by 13 inches, maximum paper size 9 3/4 by 14 inches -- for Model 1250. Most of the Experiment Stations have this type of multilith machine.

(11) We are the official correspondents in the United States of the PLANT PROTECTION BULLETIN published monthly by the United Nations Food and Agriculture Organization. We would appreciate it if plant pathologists would send us suitable material from time to time for inclusion in our monthly summary reports. Please mark it clearly so that we will know it is intended for the Bulletin. (See PDR 36: 492; 37: 637) -- P. R. M.